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JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 5, PP. 331–347, 1 TEXT-FIG., PLS. 48–50, JULY, 1936

NEW SILURIAN BRACHIOPODS OF THE FAMILY TRIPLESIIDAE

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ABSTRACT

The relative values of the characters of the members of the family Triplesiidae are discussed; the characters of the ventral beak region and of the dorsal interior are used to define the family, those of the exterior to define the genera. Five genera, 2 subgenera, 18 species, and a variety are described; of these a genus, a subgenus, 16 species, and the variety are new. The forms described come mainly from the St. Clair limestone of Arkansas; one each from the Brassfield formation of Arkansas, the Criner formation and the Chimneyhill limestone (?) of Oklahoma, the Waldron formation of Tennessee, the Borkholm formation of Estonia, and the Silurian of Gotland.

The present paper describes a number of new triplesiids, chiefly from Silurian rocks of the United States. Most of them are from the St. Clair limestone, in which triplesiids of certain types are abundant; it is the only formation in the United States known to yield species of *Brachymimulus* and *Streptis*, and the presence in it of still another genus, a very bizarre type, lends added interest.

The St. Clair material described here has been accumulated by several collectors. By far the largest portion was collected by R. D. Mesler, of the U. S. Geological Survey. H. D. Miser, also of the Geological Survey, and the authors have contributed notably to the collections.

All of the type-specimens of the new species described are deposited in the U. S. National Museum.

In the systematic part of the paper the following genera, subgenera, and species are described:

Brachymimulus americanus Ulrich and Cooper, n. sp.
Brachymimulus elongatus Ulrich and Cooper, n. sp.
Cliftonia (*Cliftonia*) *bellula* Ulrich and Cooper, n. sp.
Cliftonia (*Oxoplecia*) *gouldi* Ulrich and Cooper, n. sp.
Cliftonia (*Oxoplecia?*) *infrequens* Ulrich and Cooper, n. sp.
Cliftonia (*Plectotreta*) *lindstromi* Ulrich and Cooper, n. subgen. and n. name.
Onychotreta messleri Ulrich and Cooper, n. gen. and sp.
Onychotreta messleri angustata Ulrich and Cooper, n. var.
Onychotreta lenta (Thomas)
Onychotreta plicata Ulrich and Cooper, n. sp.
Onychotreta multiplicata Ulrich and Cooper, n. sp.
Onychotreta miseri Ulrich and Cooper, n. sp.
Streptis glomerata Ulrich and Cooper, n. sp.
Streptis incompta Ulrich and Cooper, n. sp.
Triplesia alata Ulrich and Cooper, n. sp.
Triplesia waldronensis (Miller and Dyer)
Triplesia praecipta Ulrich and Cooper, n. sp.
Triplesia rostellata Ulrich and Cooper, n. sp.
Triplesia juvenis Ulrich and Cooper, n. sp.

RELATIVE VALUES OF CHARACTERS IN THE TRIPLESIIDAE

Several years ago the junior author (1) proposed the thesis that family characters of brachiopods are to be found principally in the dorsal interior and in the region around the ventral beak, and that additional

family characters are to be found in the pallial markings of both valves. Evidence supporting this thesis is exhibited by the Orthidae, Pentameridae, Strophomenidae, and the great group of terebratuloids. The family that forms the subject matter of this paper brings additional evidence in another group of shells.

If the reader will examine the genera described herein he will discover that the family characters defined in the next section of the paper are clearly exhibited in each genus. He will also notice that the features of the dorsal cardinalia are the more persistent, presenting practically identical structures in each of the genera. On the other hand, the ventral valve departs somewhat from the rule in its internal as well as its external form. The dental plates of the ventral valve may or may not be developed to the same degree in all species of a genus. Indeed, they differ in strength even within the same species, and ocasionally they seem to be completely wanting.

If it is clear that the family Triplesiidae is characterized by a certain definite interior, it is equally clear that its genera are distinguished by definite exterior characteristics and that these constitute the sole basis for distinction. The genus *Triplesia* is smooth and has a fold on the dorsal valve; *Brachymimulus* is likewise smooth, but the fold is on the ventral valve and the dorsal valve is rather deeply sulcate; *Cliftonia* is like *Triplesia* in having the fold on the dorsal valve but it is multicostellate or multicostate, with the costae covered by rather distant concentric lamellae; *Oxoplecia* is very much like *Cliftonia*, s.s., in its ornamentation, but the concentric lamellae are finer and less distant; *Plectotreta* is plicate and strongly lamellose; *Streptis* differs from all of the other genera in the possession of concentric frills; *Onychotreta* is multicostate, but its ventral valve is greatly elongated. One specimen in the collections suggests still another genus, undescribed, a costellate or costate shell with the external shape of *Brachymimulus*. The specimen is a ventral valve, and in the absence of a corresponding dorsal valve and better material it has seemed wise to omit further consideration of it from this paper.

SYSTEMATIC DESCRIPTIONS

Family TRIPLESIIDAE Öpik

Most of the species comprising the Triplesiidae were originally assigned to *Orthis*, *Spirifer*, and *Atrypa*, genera of widely separated families. In most of these forms the internal features were unknown or inadequately understood, and the classification was based on similarity of external appearance. When eventually the internal characters were studied, new genera were instituted and the group brought together as a subfamily under the Strophomenidae. This subfamily has usually been inadequately defined as "Biconvex strophomenoids with marked fold and sinus." Beside the external characters so described, other features are common to the included genera—the deltidium is flat and also flush with the surface of the interareas, as in *Stropheodonta;* an apical foramen is present; and the cardinal process is long and forked. Realizing the unusual characters of the group Öpik (2) elevated it to family rank.

We now briefly define the family as follows:

Shell commonly biconvex, with a wide delthyrium covered by a flat deltidium; foramen small, apical. Dorsal interior with an elongated, forked cardinal process and short, divergent brachial process. Chilidium modified, often vestigial. Shell substance impunctate.

The family characters are discussed in greater detail in the succeeding paragraphs.

Foramen.—An apical foramen is common to all of the known members of the family (Pl. 48, figs. 20, 32; pl. 50, figs. 10, 18). It is commonly minute and usually located at the very apex, in a position corresponding to that known as "epithyrid" in the terebratuloids, i.e., the foramen scarcely perforates the symphytium, but usually excavates a substantial portion of the ventral umbo anterior to the beak. Such an excavated or resorbed beak has been observed in most of the genera described in this paper. The foramen is frequently round but is not uncommonly elongated, owing to resorption of the beak in an anterior direction. Some specimens of the new genus *Onychotreta* seem to exhibit an unusually long foramen (Text-fig. 1*c*).

Deltidium.—This structure in all known genera is a perfectly flat plate built across the delthyrium flush with the surface of the palintrope or interarea (Pl. 48, figs. 8, 20; pl. 49, fig. 32; pl. 50, figs. 10, 18, 30). In well-preserved specimens an elevated line or fold in the center of the deltidium usually runs from the foramen to the front margin. This fold has commonly been mistaken for the deltidium itself. It is clear, however, from examination of free ventral valves and from moistening the deltidial region of other specimens with water, glycerine, or oil, that this narrow elevation covers only a part of the delthyrium. In all brachiopods that have a deltidium the margin of the delthyrium defines the plate and is located between the teeth. On a moistened interarea and deltidium of a triplesiid the margin of the delthyrium, which is buttressed by a thickening produced by the progressive growth of the teeth, is visible as a dark, oblique line running from the beak to the tooth.

The narrow elevation mentioned above is a median fold of the deltidium associated with the chilidium. The latter in all of the Triplesiidae known to the writers is a narrow plate that fits into a slot or reentrant at the anterior margin of the deltidium. The narrow fold is thought to be the growth-trace of the reentrant in which, or underlying which, the chilidium is located. A similar ridge produced by the cardinal process may be noted in the strophomenoid genera *Scacchinella* and *Meekella*.

Cardinalia.—The cardinalia consist of a large cardinal process, small brachial processes, and a vestigial chilidium.

Cardinal process: Owing to the usually great convexity of the dorsal valve, the cardinal process has been greatly elongated. It has the shape of a large, two-pronged fork; the shaft, usually circular in cross-section, more or less bent at its junction with the valve; each prong of the fork bearing impressions for two diductor muscles, one on each side of a more or less deep groove in the posterior surface (Pl. 48, figs. 21, 26, 29; pl. 49, figs. 17, 23; pl. 50, figs. 22, 26, 28, 34). The cardinal process is variable in the same species. In some specimens it is rather stout, in others comparatively slender. In *Onychotreta* and *Brachymimulus* the shaft is short, but the prongs of the fork are exceedingly long and slender (Text-fig. 1*d*).

Brachial processes: In all known genera small, blunt protuberances directed anterolaterally on each side of the shaft of the cardinal process.

Chilidium: As is to be expected in a shell in which the notothyrium has completely disappeared, the chilidium, when present at all, is greatly modified. In all specimens of *Triplesia* and *Oxoplecia* in which the chilidium has been observed, it has proved to be a semicircular or

crescentic plate, usually very small, overlying the base of the shaft of the cardinal process and in contact with the posterior margin. The sides of this plate are often cemented by callus to the brachial processes (Pl. 48, fig. 34; pl. 49, fig. 23; pl. 50, figs. 22, 34). The chilidium observed in specimens of *Streptis* and *Brachymimulus* is rather more triangular than that in *Oxoplecia* and *Triplesia*. In *Onychotreta* it is triangular, wider than long, with the sides cemented to the brachial processes. In one specimen the

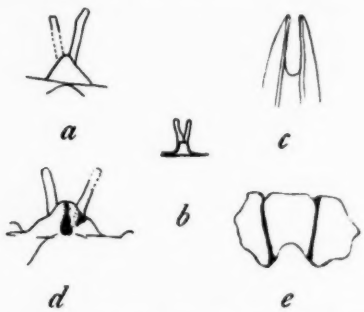

FIG. 1—Camera lucida sketches of triplesiids; enlargements approximate. *a*. *Brachymimulus americanus* Ulrich and Cooper, n. sp., ×8; cardinal process and chilidium; paratype, U.S.N.M. 91876*a*. *b*, *Streptis glomerata* Ulrich and Cooper, n. sp., ×9; cardinal process and chilidium; paratype, U.S.N.M. 91895 (Pl. 50, fig. 4). *c–e*, *Onychotreta mesleri* Ulrich and Cooper, n. gen. and sp.; *c*, apex of ventral valve, paratype, U.S.N.M. 91884*e*, from ventral side, showing the foramen and course of the dental plates, ×4; *d*, cardinal process and chilidium, ×7, paratype, U.S.N.M. 91884*d*; *e*, cross-section of a ventral valve, about 6 mm. from the beak, showing the strong dental plates, ×4.

apex of the triangle is pinched up in a posterior direction on each side of a narrow and shallow groove. Behind the groove, in a dorsal direction, there appears to be an elongate foramen. Although not all of the prepared specimens exhibit this apparent foramen, it does not seem to be an accidental feature (Pl. 49, fig. 23; text-fig. 1*d*).

Shell structure.—The shells of American species of *Brachymimulus*, *Onychotreta*, and *Streptis* discussed in this paper are too thin to permit sectioning in order to determine structure. It was possible, however, to determine some details of shell-structure in American specimens of *Cliftonia*, *Oxoplecia*, and *Triplesia*, and of European specimens of *Brachymimulus* and *Streptis*. Endo-punctae were not seen in any of the genera, European or American, nor was any trace discovered of the pseudopunctae characteristic of the strophomenoids. So far as the internal surfaces of the various genera could be observed, no granules (Wärzen) are present. The absence of these characteristic strophomenoid features from the Triplesiidae lends force to Öpik's remark that it is questionable that this group of brachiopods actually belongs to the Strophomenacea. The shell structure is more like that of an orthoid than that of any strophomenoid known to us. However, determination of the true nature and relationships of these most interesting genera must be left to the future.

Genus BRACHYMIMULUS Cockerell, 1929

Mimulus BARRANDE, *1879*, Syst. Sil. Bohême, vol. 5, pl. 1, fig. 3; pl. 9, fig. 4.—HALL and CLARKE, *1892*, Paleont. New York, vol. 8, pt. 1, p. 272.—REED, *1906*, Geol. Survey India, Mem., Paleont. Indica, n.s., vol. 2, no. 3, p. 99.—THOMAS, *1928*, Denison Univ. Sci. Lab., Jour., vol. 23, p. 137.

Brachymimulus COCKERELL, *1929*, Nautilus, vol. 42, p. 105, Philadelphia.

Exterior smooth, as in *Triplesia*, but differing in its well-developed fold on the ventral valve and corresponding sulcus on the dorsal valve. This reversed location of fold and sulcus is unusual in brachiopods, for relatively few genera are known in which it occurs. Some St. Clair specimens exhibit an elongation of the ventral beak, several showing a development comparable to that of *Onychotreta* (Pl. 48, fig. 27).

Internal features of St. Clair specimens of *Brachymimulus* those diagnostic of the family. Interarea and deltidium together

forming a flat shelf (Pl. 48, fig. 8); deltidium with usual medial fold. Dental plates short, widely divergent, as would be expected in a shell with attenuate beak. In *B. americanus* cardinal process with stout shaft, but prongs of the fork long and slender (Text-fig. 1*a*). Overlying base of shaft, a small triangular chilidium; lateral callus extensions of this plate buttress short brachial processes.

BRACHYMIMULUS AMERICANUS Ulrich and Cooper, n. sp.

Plate 48, figures 1, 2, 7, 8, 18, ?17.
Text-figure 1*a*

Mimulus perversus THOMAS, *1928*, Denison Univ. Sci. Lab., Jour., vol. 23, p. 138, pl. 36, fig. 11.

Shell small, subpentagonal in outline; greatest width a little in front of middle; surface nearly smooth, marked only by concentric growth-lines. Ventral valve pentagonal; beak pointed, strongly convex in anterior profile but gently convex in lateral profile; umbo gently concave; fold variable in width, moderately convex, defined at the front third of the shell only and marked off by deep oblique sulci; interareas narrow. Dorsal valve transversely subelliptical in outline, margins rounded, greatest width near the middle, rather strongly convex in lateral profile; umbo convex; beak low, scarcely reaching the hinge-margin; sulcus developed at the front only; tongue elongate-rounded, its transverse contour very gently convex; lateral plicae, bounding the sulcus, rounded.

Measurements: Holotype, 7.5 mm. long, 8.5 mm. wide, 5.3 mm. thick. Paratype 1, 6 mm. long, 6.5 mm. wide, 4 mm. thick; paratype 2, 5 mm. long, 5 mm. wide, 3 mm. thick.

Types: Holotype, U. S. Nat. Mus. 91876; paratypes, U. S. Nat. Mus. 91877, (1) 91907, (2) 91907*a*, 92001. Doubtful specimen, U. S. Nat. Mus. 91879.

Horizon and locality.—Common in the lower third of the St. Clair limestone at Cason Mine, 3 miles north-northeast of Batesville; near Searcy Mine, 9 miles north-northeast of Batesville; near Providence; all in Arkansas. Doubtfully, 6 miles east of St. Joe, Arkansas.

Discussion.—This species has been incorrectly referred to *B. perversus* (Barrande) (Pl. 48, figs. 3, 6, 12), from which it differs in that it is smaller and narrower, and has the sulcus less developed. The shallow, wide sulcus of *B. americanus* corresponds to a low, broad fold unlike that of *B. perversus*, and the tongue is more rounded. The hinge is narrower.

BRACHYMIMULUS ELONGATUS Ulrich and Cooper, n. sp.

Plate 48, figure 27

This species differs from *B. americanus* in the extreme elongation of the ventral beak, attaining almost the dimensions of a ventral valve of *Onychotreta*. The holotype has a strong, wide fold.

Measurements: Holotype, length, 15 mm. plus at least 2 mm. now broken away; width, 10 mm.

Holotype: U. S. Nat. Mus. 91878.

Horizon and locality.—St. Clair limestone near Searcy Mine, 9 miles north-northeast of Batesville, Arkansas.

Genus CLIFTONIA Foerste, 1909

Cliftonia FOERSTE, *1909*, Denison Univ. Sci. Lab., Bull., vol. 14, p. 81.

Cliftonia, as here conceived, includes beside *Cliftonia*, s.s., the subgenera *Oxoplecia* Wilson and *Plectotreta* Ulrich and Cooper.

The primary generic characters are the possession of radial and concentric ornamentation.

Genotype: *C. striata* Foerste, from the Brassfield formation of western Tennessee (Pl. 48, figs. 25, 31).

Subgenus CLIFTONIA Foerste, 1909

The type species, *C. striata* Foerste (Syntypes, U. S. Nat. Mus. 87009), is small and has the external aspect of a "small *Atrypa*." Indeed, the resemblance to a small *Atrypa* affords the best description of the appearance of the shell, for the outline is subcircular and the exterior exhibits strong, distant lamellae

that undulate over the ribs and project obliquely from the shell. The interior of the dorsal valve, so far as can be seen in the known specimens, has essentially the family features. In the ventral valve on the other hand, the dental plates are weaker and the rostral cavity is smaller than is usual in the older genera. The

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EXPLANATION OF PLATE 48

Figures in parentheses are catalogue numbers of specimens in the U. S. National Museum.

FIGS. *1, 2, 7, 8, 18—Brachymimulus americanus* Ulrich and Cooper, n. sp. *1, 2, 7*, Dorsal, anterior, and lateral views, ×2, of holotype (91876). *8*, Interarea, ×3, of a paratype (91877), showing the deltidium and long, narrow elevation along the middle of it; *18*, ventral view, ×2, of same specimen. St. Clair limestone, Cason Mine, 3 miles north-northeast of Batesville, Arkansas. (p. 335)

17—Brachymimulus cf. *B. americanus* Ulrich and Cooper, ventral valve, ×2, with sulcus in fold; figured specimen (91879) from St. Clair limestone, 6 miles east of St. Joe, Arkansas. (p. 335)

3, 6, 12—Brachymimulus perversus (Barrande), hypotypes, ×2, shown for comparison with *B. americanus*. *3*, Ventral view showing great width of valves (88463); *6, 12* dorsal and anterior views (88463*a*). Silurian, Lodeniče, Czechoslovakia. (p. 335)

4, 5—Triplesia juvenis Ulrich and Cooper, n. sp., ventral and dorsal views, ×3, of holotype (91869). Upper part of St. Clair limestone, Cason Mine, Arkansas. (p. 347)

9, 13—Triplesia rostellata Ulrich and Cooper, n. sp., ventral and lateral views, ×2, of holotype (91868), Waldron shale, Newsom, Tennessee. (p. 347)

10, 11—Triplesia praecipta Ulrich and Cooper, n. sp., syntypes, ×3. *10*, Ventral view (91867); *11*, dorsal view (91867*a*). Uppermost St. Clair limestone, Cason Mine, Arkansas. (p. 346)

14–16, 19—Cliftonia (*Cliftonia*) *bellula* Ulrich and Cooper, n. sp., lateral, dorsal, ventral, and anterior views, ×2, of holotype (91881). Boulder of Chimney Hill limestone in Johns Valley shale, Johns Valley, Oklahoma. (p. 337)

20, 24, 29, 33—Cliftonia (*Cliftonia*) *tubulistriata* (Savage), hypotypes. *20*, Interarea, ×2, of a silicified ventral valve showing the elongate apical foramen, flat deltidium, and teeth (91880); *24*, dorsal view, ×2, showing the ornamentation (91880*a*); *29*, posterior portion of a dorsal valve, ×3, showing the cardinal process (91880*c*); *33*, group of valves, ×2, on a small slab (91880*b*). Silurian (Noix), Henderson's Farm, 3 miles west of Louisiana, Missouri. (p. 337)

21, 28, 32, 34, 35—Triplesia ortoni (Meek), hypotypes. *21, 28*, Cardinal process from above, cardinal process and brachial processes from below, ×2 (91871); *32*, posterior view, ×2, of ventral valve, showing the foramen, teeth, and deltidium (note fold in central part of deltidium) (91871*b*); *34, 35*, dorsal valve, ×4 and ×2, showing broken cardinal process and vestigial chilidium (91871*a*). Brassfield formation, Soldiers' Home, Dayton, Ohio. (p. 345)

22, 26—Triplesia cf. *T. extans* (Hall), figured specimen (91870), ×3; *22*, cardinal process from below; *26*, same from above; chilidium is rudimentary. Lower Trenton, Martinsburg, New York. (p. 333)

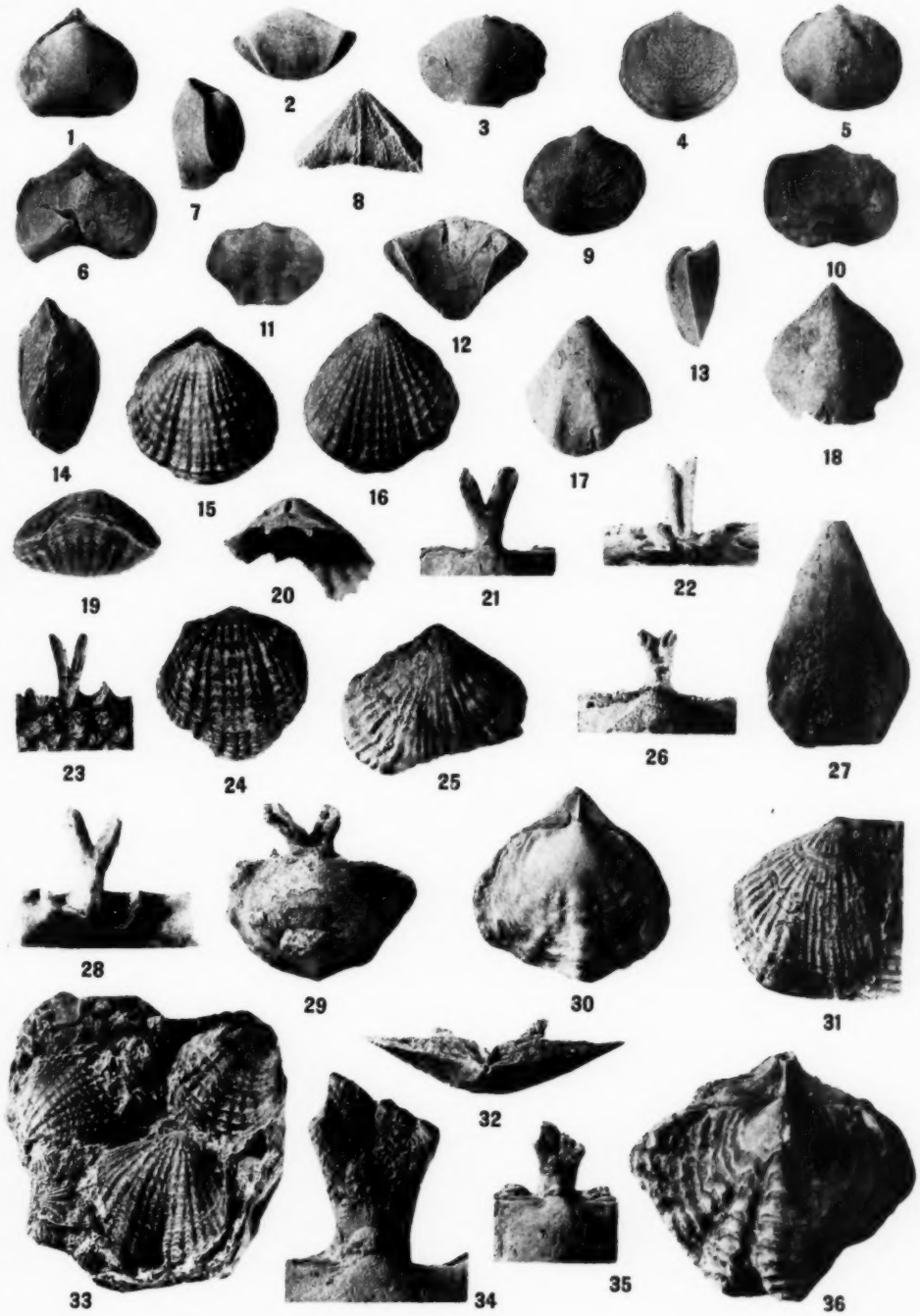
23—Triplesia alata Ulrich and Cooper, n. sp., syntype (91872*a*), ×2, under side of cardinal process and brachial processes. Brassfield formation, Cason Mine, Arkansas. (p. 346)

25, 31—Cliftonia (*Cliftonia*) *striata* Foerste, syntype (87009), ×2; *25*, mold of anterior of ventral valve, showing impression of the short dental plates and filling of the foramen; *31*, plasticine replica of exterior of same, showing ornamentation. Brassfield formation, Clifton, Tennessee. (p. 335)

27—Brachymimulus elongatus Ulrich and Cooper, n. sp., holotype (91878), an incomplete specimen, ×2, showing the elongate beak. St. Clair limestone, Searcy Mine, 9 miles north-northeast of Batesville, Arkansas. (p. 335)

30—Cliftonia (*Plectotreta*) sp., dorsal view, ×4, of a young specimen showing well the fold on the deltidium; appears to differ specifically from *C.* (*P.*) *lindströmi* Ulrich and Cooper. British Mus. B-13575; cast, U.S.N.M. 91928. Silurian, Wisby, Gotland. (p. 333)

36—Cliftonia (*Plectotreta*) *lindströmi* Ulrich and Cooper, n. subgen. and n. name, hypotype, ×4; dorsal view showing the strong radial plications, apical foramen, fold on the deltidium, and the strong concentric lamellae. British Mus. 73220; cast, U.S.N.M. 91927. Silurian, Gotland. (p. 339)



Ulrich and Cooper, Silurian Brachiopods

UNIV. OF MICH.

chief claims of *Cliftonia* to subgeneric rank must rest on its tendency to asymmetry and its external ornament, features that appear, as pointed out on p. 331, to be sound criteria.

The ornamentation, outline, and asymmetry of *Cliftonia*, s.s., distinguish it from *Oxoplecia;* the weaker ornamentation distinguishes it from *Plectotreta.*

According to the definition of *Cliftonia* presented by Foerste, *Atrypa tubulistriata* Savage (Pl. 48, figs. 20, 24, 29, 33) and a new species described below belong to this subgenus.

CLIFTONIA (CLIFTONIA) BELLULA Ulrich and Cooper, n. sp.

Plate 48, figures 14–16, 19

Shell small, atrypoid in appearance, suborbicular in outline; valves unequally convex, dorsal valve being the more convex. Hinge narrow, equal to about one-third the width of the shell. Surface covered by low, rounded costellae, crossed by concentric lamellae that are prolonged into rather sharp spines 1 mm. long. Ventral valve with wide, shallow sulcus, bounded by low lateral areas; sulcus originates 3 mm. in front of the beak; at front of shell, 6 costellae in sulcus; ventral umbo swollen, beak pointed; interarea narrow, curved. Dorsal fold low, broadly rounded, obsolete on the umbo, which is smooth and swollen; anterior broadly rounded in front.

Measurements: Holotype, 10.5 mm. long, 11 mm. wide, 5.5 mm. thick.

Holotype: U. S. Nat. Mus. 91881.

Horizon and locality.—Boulder in the Johns Valley shale, thought to have come from the Chimney Hill limestone, of Early Silurian (Medinan) age; Johns Valley, Oklahoma.

Discussion.—This species differs from *C. striata* Foerste in its stronger, less numerous costellae and stronger, more distant concentric lamellae; from *C. tubulistriata* in having finer, more numerous costellae. *C. bellula* appears to be intermediate between the two species in its ornamentation.

Subgenus OXOPLECIA Wilson, 1913

Oxoplecia WILSON, *1913*, Victoria Mem. Mus., Bull., vol. 1, pp. 81–86.

Oxoplecia, according to Miss Wilson, differs from *Triplesia*

in having the surface covered with plications or striae, which increase by interpolation and bifurcation; in the large, triangular, slightly concave cardinal area of the pedicle valve; in the broader, usually flat deltidium; in the shorter cardinal process; and in the longer beak of the pedicle valve.

The important character in this description, the one feature mentioned that is constant, is the ornamentation. The remainder are either specific or individual characters. The flat deltidium is, of course, common to the whole family. Miss Wilson noted the strong concentric growth-lines that are characteristic of all the species referred by her to her genus, with the exception of *Triplesia grayiae* (Davidson). As here defined, *Oxoplecia* contains many species and has a long vertical range, from Chazyan well into the Middle Silurian. Throughout this known range the type of ornamentation characteristic of the subgenus persists with little variation.

Cliftonia, s.s., and *Oxoplecia* appear to be closely related stocks that may be separated on minor characters into subgeneric groups, but are not worthy of higher rank. It is very likely that the finely imbricate *Oxoplecia* gave rise to *Cliftonia* by increased development of the concentric lamellae.

Cliftonia, s.s., is atrypoid in ornamentation and subcircular in outline. *Oxoplecia*, on the other hand, has fine, rather closely spaced, elevated concentric lines over the entire shell, and is usually more transverse. According to this definition, "*Triplesia*" *niagarensis* Hall and Clarke, owing to its transverse outline, would probably belong to *Oxoplecia;* likewise *Oxoplecia? infrequens* Ulrich and Cooper. The question as to these two species cannot be conclusively answered because the finer details of their surface markings are unknown.

In formations of Chazyan age in the southern Appalachians a large number of species of *Oxoplecia* has been collected. These shells are all characterized by a deep ventral sulcus, a strong fold, and multicostellate exterior, the coarser radial lines being crossed by fine elevated concentric lines. It is expected that these forms will be dealt with in an account of Chazyan Brachiopoda of North America now in preparation.

CLIFTONIA (OXOPLECIA) GOULDI Ulrich and Cooper, n. sp.

Plate 50, figures 8, 15, 18, 19, 23, 28, 32, 36

Cliftonia gouldi DECKER, *1931*, Oklahoma Geol. Survey, Bull. 55, p. 42, pl. 13, fig. H (*nomen nudum*).

Shell large, transversely elliptical in outline; lateral extremities rather narrowly rounded, front margin subtruncate. Valves with about the same depth but dorsal valve the more convex of the two. Length of hinge-line little more than half the width of the valves. Surface multicostellate, with 14 to 20 costellae on flanks of shell, 8 to 10 in sulcus; whole surface covered by fine elevated concentric lines, 7 in 1 mm. at middle of valve. Ventral valve rather gently, evenly convex in profile, with shallow median sulcus, gently convex lateral areas, gentle lateral slopes; sulcus originates 5 mm. from the beak, widens gradually to front of valve, where it occupies about one-half the width of the valve; beak smooth, umbo gently convex. Fold of dorsal valve low, rather flat-topped, elevated a little above lateral areas, which are gently convex but with steep lateral slopes.

EXPLANATION OF PLATE 49

Figures in parentheses are catalogue numbers of specimens in the U. S. National Museum.

FIGS. *1, 8, 13—Onychotreta plicata* Ulrich and Cooper, n. gen. and sp., syntypes. *1*, Dorsal valve, ×2 (91886); *8, 13*, ventral valve, ×1 and ×2 (91886*a*). St. Clair limestone, Searcy Mine, 9 miles north-northeast of Batesville, Arkansas. (p. 343)

2–5—Onychotreta lenta (Thomas), hypotypes; *2*, ventral valve, ×2 (91888*a*); *3, 5*, an incomplete ventral valve, ×1 and ×2 (91888); *4*, dorsal valve, ×2, showing the peculiar ornamentation (91888*b*). St. Clair limestone, Cason Mine, 3 miles north-northeast of Batesville, Arkansas. (p. 342)

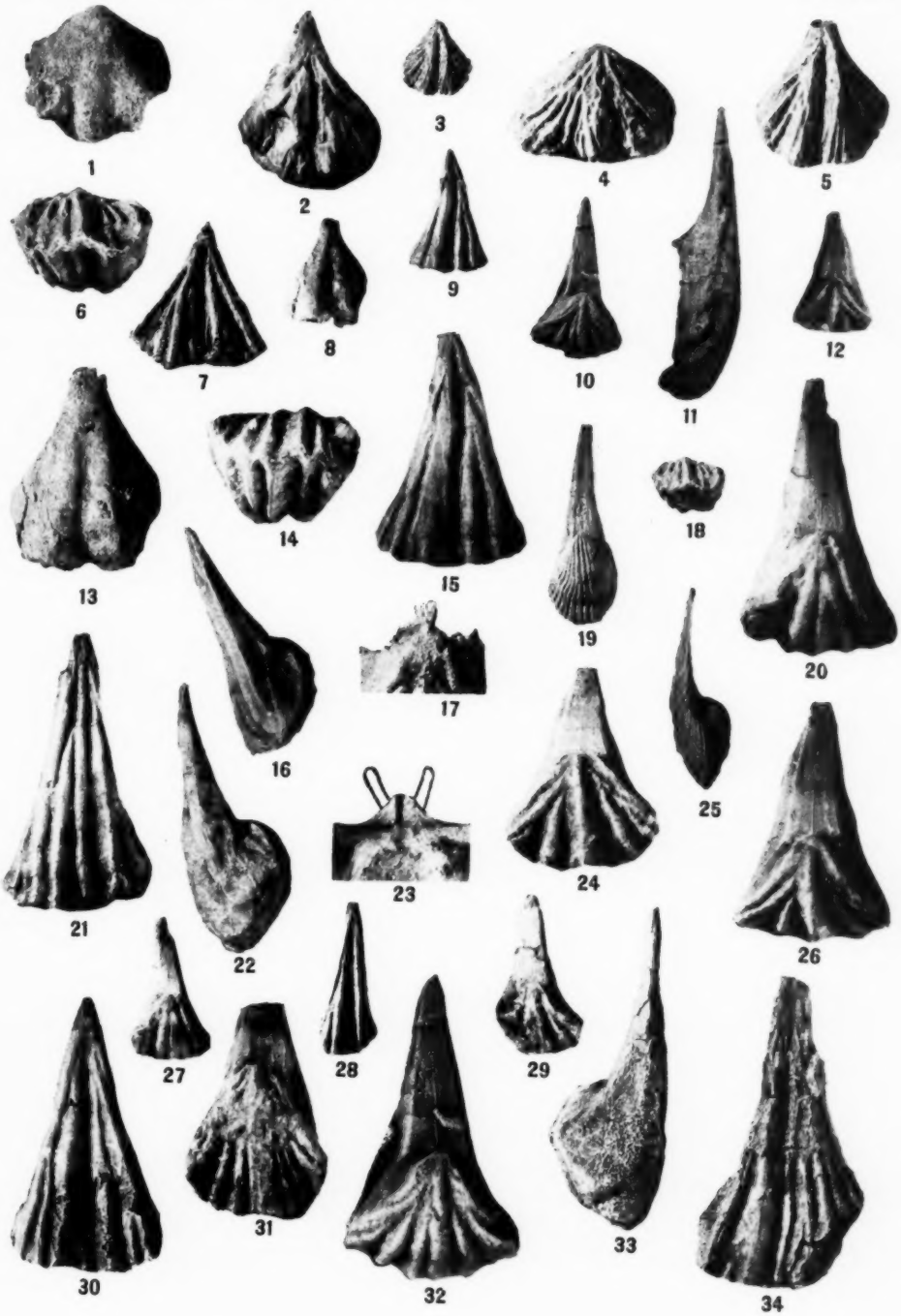
7—Onychotreta multiplicata Ulrich and Cooper, n. gen. and sp., syntype (91887), ventral view, ×2, of an average specimen. St. Clair limestone, Searcy Mine, Arkansas. (p. 343)

9–12, 14–17, 23, 24, 26, 28–30, 32–34—Onychotreta mesleri Ulrich and Cooper, n. gen. and sp. *9, 12*, Ventral and dorsal views, ×1; *14–16, 24, 26*, anterior, ventral, lateral, dorsal, and cardinal views, ×2, of holotype (91883); *24* is tilted to show complete view of the dorsal valve; *26* is posed to show the interarea and small longitudinal elevation on the deltidium. *10, 32*, Wax replica, ×1 and ×2, of a nearly complete individual prepared from a paratype (91884). *11*, Side view, ×2, showing the very narrow beak, paratype (91884*a*). *17*, Posterior view, ×4, showing an imperfect cardinal process near its base, paratype (918884*c*). *23*, Dorsal view, ×12, showing the chilidium; the cardinal process is actually visible in the specimen, but could not be photographed, and its position is indicated; paratype (91884*d*). *28*, An unusually long, slender ventral valve, ×1, paratype (91884*b*). *29, 33, 34*, Dorsal view, ×1; lateral and ventral views, ×2, paratype (91884*f*). *30*, Large ventral valve, ×2, paratype (91884*e*); see also text-fig. 1*c*. St. Clair limestone, Searcy Mine, Arkansas. (p. 340)

6, 18, 31—Onychotreta mesleri angustata Ulrich and Cooper, n. gen., sp., and var., holotype (91885); *6, 18*, views, ×2 and ×1, of the anterior; *31*, dorsal view, ×2, showing the narrow form. St. Clair limestone, Searcy Mine, Arkansas. (p. 341)

19, 25—Terebrirostra lyra (Sowerby), hypotype (88501), ×1; dorsal and lateral views for comparison with *Onychotreta*. Cretaceous, Cenomanian, Cape de la Hêve, near Le Havre, France. (p. 340)

20–22, 27—Onychotreta miseri Ulrich and Cooper, n. gen. and sp., holotype (91882); *20–22*, dorsal, ventral, and lateral views, ×2; *27*, dorsal view, ×1. St. Clair limestone, Searcy Mine, Arkansas. (p. 343)



Ulrich and Cooper, Silurian Brachiopods

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Measurements: Holotype, 17 mm. long, 21 mm. wide, 11 mm. thick. Paratype 1, 17 mm. long, 23 mm. wide, 10.5 mm. thick.

Types: Holotype, U. S. Nat. Mus. 91897; paratype 1, U. S. Nat. Mus. 91898; other paratypes, U. S. Nat. Mus. 91898*a*,*b*, 91899.

Horizon and locality.—Criner formation at Rock Crossing of Hickory Creek, 3 miles west of Overbrook; 3 miles east of Pooleville; both in Oklahoma. Numerous other localities on the flanks of the Arbuckle uplift.

Discussion.—This species suggests *O. calhouni* Wilson, from the Utica formation of Ottawa, but differs in possessing a wider fold and a much more elevated beak on the ventral valve. *Cliftonia occidentalis* Butts is rather similar, but is a rounded shell with a more convex ventral valve and a rather swollen ventral umbo.

CLIFTONIA (OXOPLECIA?) INFREQUENS Ulrich and Cooper, n. sp.

Plate 50, figure 12

A single specimen, a ventral valve, wider than long, wide-hinged, subelliptical in outline, gently convex in profile; beak pointed, a little incurved. Sulcus defined from a point a little in front of beak, deep at anterior of shell; divided from lateral portion of shell by an abrupt ridge on each side. Surface multicostellate (?), 6 costellae occupying sulcus at front of shell.

Measurements: Holotype, length, 14 mm.; width, 16 mm.

Holotype: U. S. Nat. Mus. 91896.

Horizon and locality.—St. Clair limestone, one mile west of Gilbert, Arkansas.

Discussion.—This species differs from *C. niagarensis* Hall and Clarke in its lesser convexity, shallower sulcus, finer costellation, and much shorter ventral tongue.

Subgenus PLECTOTRETA Ulrich and Cooper, n. subgen.

Etymology: πλεκτός, folded; τρητός, perforated.

Genotype: *P. lindströmi* Ulrich and Cooper.

This subgenus is characterized by a spiriferoid exterior with strong concentric lamellae and strong radial plications. It is intermediate between *Streptis* and *Cliftonia*, s.s. From *Streptis* it differs in having strong radial plications and in lacking the finer radii overlying the concentric lamellae; from *Cliftonia*, s.s., in the possession of strong radial plications rather than numerous radial costellae.

PLECTOTRETA LINDSTRÖMI Ulrich and Cooper, n. name

Plate 48, figure 36

Strophomena nasuta LINDSTRÖM (not Conrad), *1860*, Ofv. K. Akad., Forh., p. 371, pl. 13, fig. 15, Stockholm.

Lindström described this interesting little species under the name *Strophomena nasuta*, overlooking its previous use by Conrad for a species from the Maysville formation of the Cincinnatian epoch. Davidson's belief (3) that his assignment of Lindström's species to the genus *Cyrtia* validated the specific name *nasuta* does not hold under the accepted rules.

Hypotype: British Mus. 73220; cast, U. S. Nat. Mus. 91927.

Horizon and locality.—Silurian, Gotland.

ONYCHOTRETA Ulrich and Cooper, n. gen.

Etymology: ὄνυξ (ὄνυχ-), claw; τρητός, perforated.

Genotype: *O. mesleri* Ulrich and Cooper.

Small, clawlike, thin-shelled; valves unequal in size, dorsal valve short, ventral valve greatly elongated; hinge-line straight; interarea a narrow space on each side of a wide delthyrium; deltidium flat, usually marked in center by a low narrow ridge; ventral beak sharply pointed, perforated by a small, elongated apical foramen; dorsal beak low. Surface multicostate. Shell substance impunctate.

Ventral interior: Strong parallel dental

plates extend from beak for fully half the length of the valve (Text-fig. 1*e*). Musculature unknown, could not be prepared because of thin shell and friable, granular matrix.

Dorsal interior: Like that of the family, i.e., with a long, forked cardinal process and short, divergent brachial processes. Chilidium triangular.

Discussion.—Onychotreta recalls most strongly the type of exterior seen in *Uncites*, *Terebrirostra* (Pl. 49, figs. 19, 25), and *Agulhasia*. The bizarre elongation of the ventral valve naturally produces an abnormal development of most of the structures connected with the hinge and the interior, and gives definition to the genus. The dorsal valve is less aberrant and it is in this valve that the family characters remain constant. As is usual in the family, *Onychotreta* has a small apical foramen and a flat deltidium with a low central fold. The deltidium, like the body of the shell, is exceedingly thin. Rostration usually produces a more or less complete loss of the interarea. In *Onychotreta* it has been reduced to a narrow space on each side of the broad delthyrium. Horizontal lines of growth are preserved on the exterior of the deltidium, and vertical lines representing the growth-traces of irregularities of the hinge-margin.

Dorsal interior: The dorsal hinge-line is straight and produced laterally to form narrow, obtusely angular ears. In front of the beak and a little anterior to the cardinal margin is a prominent triangular chilidial plate, tapering toward the extremities of the ears and with its rounded apex ventral to the hinge (Text-fig. 1*d*). The plate is marked by a shallow, narrow sulcus extending from the apex to near the base, and at right angles to the latter. Just anterior to, and on each side of, the apex extend the forks of the cardinal process. When seen in oblique light on the unmoistened paratype (U. S. Nat. Mus. 91884*d*) which best shows the chilidium, the groove in the center of the plate appears to be a narrow sulcus with straight sides (Pl. 49, fig. 23). Under glycerine an additional structure may be seen (Text-fig. 1*d*), an oval opening near the base of the triangle and in the sulcus. From this opening to the apex a line of suture in the sulcus suggests that the chilidium is composed of two ankylosed plates. This paratype is the only specimen in the collection showing all of the above features.

The cardinal process of *Onychotreta* is like that of other members of the family. The shaft is rather short, well hidden under the beak, and there is considerable variation in the stoutness of the prongs, some being relatively slender. The prongs of one cardinal process measured one millimeter in length. The nature of the brachial supports was not satisfactorily determined, owing to the fragility of the specimens, but preparations indicate them to be similar to those of other members of the family. They are set some distance laterally from the beak and cardinal process, and appear to be short, stout, tapering plates. A few specimens show a thickening of calcareous material extending from the lateral extremities of the chilidium to the inner faces of the brachial processes where it serves to reinforce those structures. The brachial processes bound deep, wide dental sockets. Owing to the unfavorable preservation, no muscular scars were observed in the dorsal valve.

ONYCHOTRETA MESLERI Ulrich and and Cooper, n. sp.

Plate 49, figures 9–12, 14–17, 23, 24, 26, 28–30, 32–34. Text-figures 1*c–e*

Exterior: Shell thin, clawlike in contour and profile; valves very unequal in size, ventral valve fully twice length of dorsal valve. Oramentation variable, of subangular costae that increase by intercalation and bifurcation.

Ventral valve: Hinge-line straight, its length slightly less than greatest width of shell; greatest convexity nearest front margin. Beak smooth for 2 mm., below which shell develops a strong median sulcus bounded on each side by a promi-

nent costa; superimposed on these major costae, minor, faint, rounded ribs that terminate on side of shell not far from beak; these represent early stages in growth of individual. Strong costae, intercalated 5 to 7 mm. from the beak on sides of costae bounding the sulcus, extend laterally toward margins of valve; additional intercalations take place towards front of valve. Number of costae variable, especially at front; in our specimens, 6 to 11. Deep but narrow median sulcus that extends from a point near beak to front margin of valve a nearly constant feature. Lateral regions, i.e., shell surfaces between lateral margins of interarea and margins of valve, when viewed ventrally, unusual, showing two distinct areas separated by a ridge; areas nearest interarea marked by growth-lines only, others bearing subsidiary oblique costae.

Dorsal valve: sub-triangular or subpentagonal in outline, widest near front margin, narrowest at umbo; cardinal extremities sub-auriculate, rounded; umbo flattened, low; beak bluntly pointed, just meeting cardinal margin. Valve most convex at umbo but only flatly convex in middle and towards front. Lateral area rather abruptly marked off from costate surface, consisting of a concave area narrowing anteriorly; this region marked by growth-lines only; lateral area of dorsal valve corresponds to the nearly smooth portion of lateral area of ventral valve. Ornamentation corresponding to that of ventral valve in appearance of the costae; umbo smooth, but in less than 2 mm. from beak a strong costa develops that may or may not continue to front margin, largely dependent on the age of the individual; in young shells median costa usually strong, elevated above level of other costae; in older shells median costa may become narrower, or may be lost among secondary and tertiary ribs that have so increased in size as to equal that of median rib; at nearly same point of appearance of median costa, lateral costae mark sides of shell; secondary, tertiary, and quaternary stages of intercalation appear between primary costae. In anterior profile the older dorsal valves are gently concave.

Measurements: Holotype and paratype 1, respectively, length, 17?, 22? mm. width, 10.7, 12? mm.; hinge width, 4, 4 mm.; length of dorsal valve, 8, 10 mm.; thickness, 6, 8 mm.

Types: Holotype, U. S. Nat. Mus. 91883. Paratype 1, U. S. Nat. Mus. 91884; other paratypes, U. S. Nat. Mus. 91884*a–f*.

Horizon and locality.—St. Clair limestone, Searcy Mine, 9 miles north-northeast of Batesville, Arkansas, where the species is very abundant near the middle of the formation, though rare at all other localities. Upper part of formation at Cason Mine, 3 miles north-northeast of Batesville; lower part of formation at St. Clair Spring, Arkansas.

Discussion.—Onychotreta mesleri differs from *O. lenta* (Thomas) in its ornamentation, size, and greater proportionate elongation of the ventral valve. Comparison with *O. messleri angustata* is made below.

ONYCHOTRETA MESLERI ANGUSTATA Ulrich and Cooper, n. var.

Plate 49, figures 6, 18, 31

One specimen differs so markedly from *O. mesleri* that it is here separated as a variety. It has a more elongate and rather narrow dorsal valve, and somewhat finer ornamentation. The fundamental plan of ornamentation, however, is like that of *O. mesleri* in that it shows a strong sulcus on the ventral valve and a correspondingly strong median costa on the dorsal valve.

Measurements: Holotype, length, 16 mm. plus 5 or 6 mm. now broken away; width, 10 mm.; hinge width, 3.6 mm.; length, dorsal valve, 10.5 mm.; thickness, 6.5 mm.

Holotype: U. S. Nat. Mus. 91885.

Horizon and locality.—Near middle of St. Clair limestone at the Searcy Spring. 9 miles north of Batesville, Arkansas.

ONYCHOTRETA LENTA (Thomas)

Plate 49, figures 2–5

Rhynchotreta lenta THOMAS, *1926*, Denison Univ. Sci. Lab., Jour., vol. 21, pp. 385, 386, pl. 54, fig. 1.

Shell small, thin, elongate, clawlike. Ventral valve roughly cuneiform; apex acutely pointed, apical angle about 45°; lateral margins concave, front margin rounded; lateral area between lateral margin and interarea flatly concave; hinge-line straight, interarea narrow; delthyrium wide. Surface fascicostate; beak smooth for distance of 2 or 3 mm.;

EXPLANATION OF PLATE 50

Figures in parentheses are catalogue numbers of specimens in the U. S. National Museum.

FIGS. *1, 2, 6, 7—Streptis grayii* (Davidson), hypotypes, ×2. *1, 2*, Dorsal and anterior views of a nearly complete individual (91889) showing the right side depressed in relation to the left side; *6, 7*, dorsal and anterior views of another individual (91889*a*) showing the left side depressed in relation to the right side. Wenlock, Dudley, England. (p. 344)

3—Triplesia praecipta Ulrich and Cooper, syntype (91867*b*), ×2; large ventral valve showing the wide sulcus. St. Clair limestone, Cason Mine, 3 miles north-northeast of Batesville, Arkansas. (p. 346)

4, 5, 9, 31—Streptis glomerata Ulrich and Cooper, n. sp. *4*, Very small, untwisted dorsal valve, ×4, paratype (91895); Tomahawk Creek, 6 miles east of St. Joe, Arkansas. *5*, Ventral valve, ×3, with left side depressed, paratype (91893); *9*, ventral valve, ×3, with right side depressed and showing part of last frill, paratype (91894); Searcy Mine, 9 miles north-northeast of Batesville, Arkansas. *31*, Dorsal view, ×6, of holotype (91892), with left side depressed; 6 miles east of St. Joe, Arkansas. St. Clair limestone. (p. 344)

8, 15, 18, 19, 23, 28, 32, 36—Cliftonia (*Oxoplecia*) *gouldi* Ulrich and Cooper, n subgen. and sp. *8, 19, 36*, Side, ventral, and dorsal views, ×1, of holotype (91897). *15, 32*, Posterior views, ×1 and ×2, showing the foramen and elevated part of the deltidium, paratype (91898). *18*, Interarea, foramen and deltidium, ×3, of paratype (91899); the suture between the sides of the interarea and the margin of the deltidium are clear, also the elevated fold along center of the deltidium. *23*, Portion of a shell, ×3, showing the fine elevated, concentric lines, paratype (91898*a*). *28*, Interior, ×2, from the anterior side; ventral valve above, showing short, thick dental plates; the short, stubby brachial processes are also visible; paratype (91898*b*). Criner formation, Rock Crossing of Hickory Creek, 3 miles west of Overbrook, Oklahoma. (p. 338)

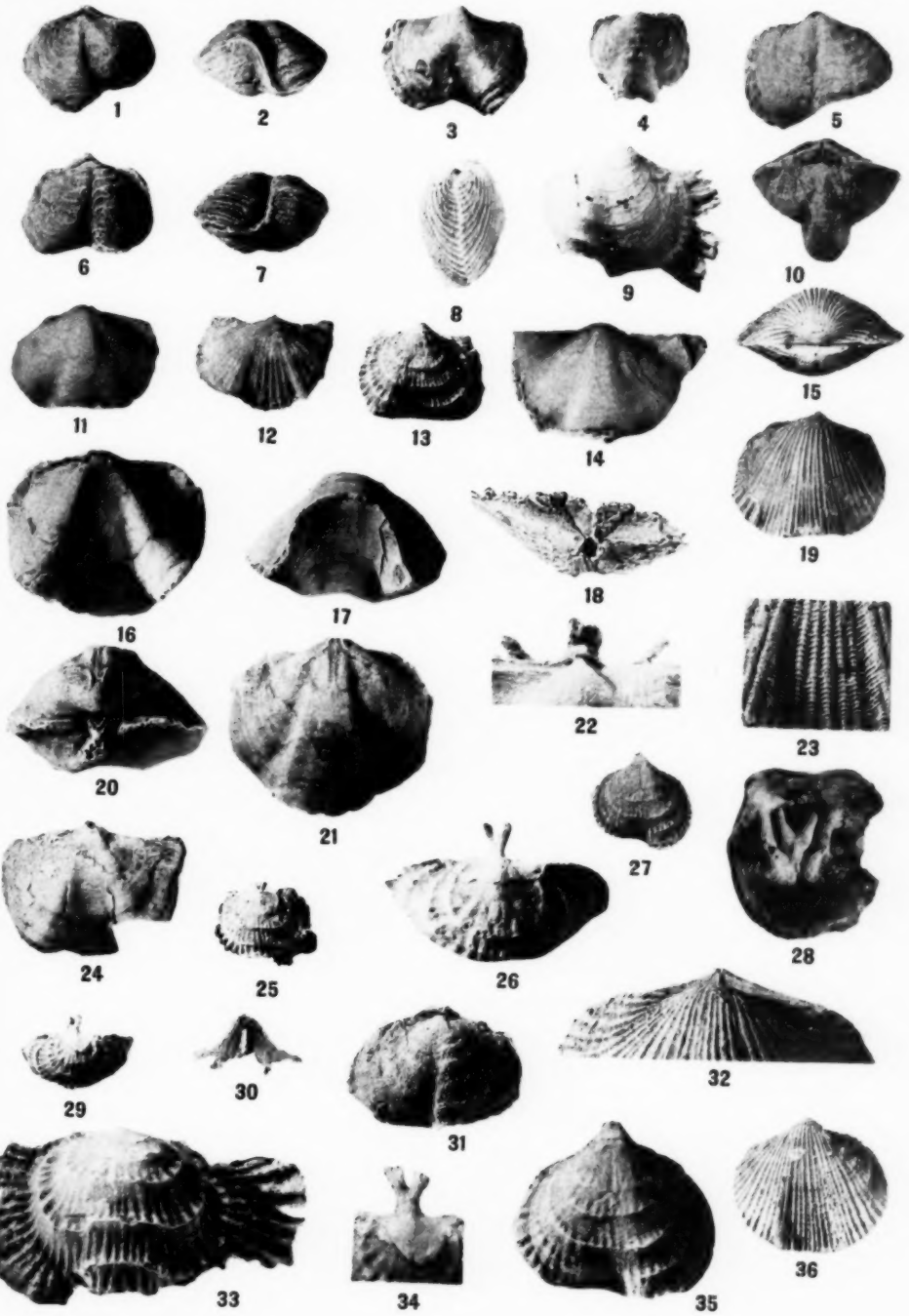
10—Streptis monilifera altosinuata Holtedahl, hypotype (91890), ×2; complete symmetrical specimen seen from dorsal side, showing interarea, foramen, and the deltidium with its elevated line. Lower Llandovery (Étage 6 *aB*), Kongelungen, Asker, Norway. (p. 344)

11, 14, 16, 17, 20, 21, 24—Triplesia alata Ulrich and Cooper, n. sp., syntypes, ×1. *11*, Dorsal valve (91874), Tomahawk Creek, 6 miles east of St. Joe, Arkansas. *14, 24*, Dorsal valve (91873) and ventral valve (91873*a*), ½ to 1 mile west of Gilbert, Arkansas. *16, 17, 20, 21*, Ventral, anterior, posterior, and dorsal views of a large internal mold (91872); *21* shows muscle scars; Cason Mine, Arkansas. Brassfield formation. (p. 346)

12—Cliftonia (*Oxoplecia?*) *infrequens* Ulrich and Cooper, n. sp., holotype (91896), ×1; ventral valve. St. Clair limestone, 1 mile west of Gilbert, Arkansas. (p. 339)

13, 25–27, 29, 30, 33–35—Streptis incompta Ulrich and Cooper, n. sp., syntypes. *13*, Ventral valve, ×2, depressed on right side (91891); compare figs. 27, 35. *25*, Dorsal valve, ×2, showing the ornamentation; *26*, cardinal process, ×4 (91891*b*). *27, 35*, Ventral valve, ×2 and ×4, showing details of ornamentation and asymmetry; *30*, interarea, ×4, showing teeth, deltidium and its central elevation (91891*a*); compare fig. 13. *29, 34*, an imperfect cardinal process, ×2 and ×4 (91891*d*); fig. 34 has been retouched to show chilidium. *33*, Dorsal valve, ×4, showing the ornamentation (91891*c*); the broad frills are preserved. Borkholm formation (F_2), Borkholm Schloss, Estonia. (p. 345)

22—Triplesia anticostiensis (Twenhofel), hypotype (91875); posterior median part of dorsal valve, ×3, showing the brachial processes, chilidium, and an imperfect cardinal process. Silurian, Jupiter River formation; Jupiter River, Anticosti. (p. 333)



Ulrich and Cooper, Silurian Brachiopods

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then two longitudinal plicae form, continuing to front margin and defining a deep V-shaped sulcus; superimposed on these plicae, numerous bifurcating, intercalating costae that form two fascicles near front of shell; similar costae on lateral slopes form two more fascicles. These secondary costae may be short, interrupted, and are usually oblique to the plicae. Thomas has aptly described the costation as "ropey" in appearance. Dorsal valve sub-triangular to subelliptical in outline; strongly convex at umbo, gently convex elsewhere; lateral areas narrow, smooth, concave. Surface plicate and fascicostate; center of valve marked by an elevated plica extending from smooth umbo to anterior margin; on each side of median plica is another, making three major undulations on surface, the whole covered by bifurcating costae superimposed on plicae to form prominent fascicles. Internal characters essentially like those of *O. mesleri*.

Measurments: Ventral valve (91888*a*), 13 mm. long, 10 mm. wide: dorsal valve (91888*b*), 8 mm. long, 10.5 mm. wide.

Hypotypes: U. S. Nat. Mus. 91888, *a*, *b*.

Horizon and locality.—St. Clair limestone, Searcy Mine, 9 miles north-northeast of Batesville; Cason Mine, 3 miles north-northeast of Batesville, Arkansas.

Discussion.—*O. lenta* (Thomas) differs very strongly from *O. mesleri* in the shorter ventral valve, the narrower lateral areas, and the "ropey" appearance of the costae superimposed on the plicae. *O. mesleri* does exhibit rarely some of the peculiar disconnected, oblique costae, but they are not distributed over the whole valve.

ONYCHOTRETA PLICATA Ulrich and Cooper, n. sp.

Plate 49, figures 1, 8, 13

Ventral valve elongate, slender at the beak; interarea and deltidium precisely like those of *O. mesleri;* two strong, rounded to sub-angular costae the sole ornamentation revealed by the material at hand; median sulcus deep, extending about two-thirds length of valve. Dorsal valve moderately convex longitudinally, rounded at umbo; beak poorly defined; surface smooth for about one-half length from umbo; front half of shell marked by three strong, rounded or subangular costae, one median costa corresponding to ventral sulcus.

Syntypes: U. S. Nat. Mus. 91886, *a*.

Horizon and locality: St. Clair limestone, Searcy Mine, 9 miles north-northeast of Batesville, Arkansas.

Discussion.—*O. plicata* may be recognized easily by the few large, simple costae. The species is apparently quite rare, for it was noted only in the collection from the type locality.

ONYCHOTRETA MULTIPLICATA Ulrich and Cooper, n. sp.

Plate 49, figure 7

O. multiplicata differs from *O. mesleri* iniits much shorter shell and in its ornamentation—two fascicles, each of four or five rather angular costae, bound a deep median sulcus in the ventral valve. Apical angle about 60°. It is a rare species.

Syntypes: U. S. Nat. Mus. 91887, *a*, *b*.

Horizon and locality.—St. Clair limestone, Searcy Mine, 9 miles north-northeast of Batesville, Arkansas.

ONYCHOTRETA MISERI Ulrich and Cooper, n. sp.

Plate 49, figures 20–22, 27

A single nearly complete shell, differs from *O. mesleri* in its more erect beak, more deeply excavated lateral areas, and very different ornamentation. Instead of the rather deep, subangular median sulcus of *O. mesleri*, the ventral valve of *O. miseri* has a shallow sulcus occupied by a low median costa that extends almost to beak. Margins of ventral valve flanked by a strong costa on each side; a strong costa intercalated between median costa and that bounding left side of valve, extending from a point 6 mm. from beak to anterior margin of valve; 8 mm. from anterior margin another costa is

implanted outside the primary costae that in early stages bound margins of valve; at anterior margin there are thus six costae. Dorsal valve very gently convex in lateral profile; broadly pentagonal in outline, with lower sides of pentagon flaring prominently; gently sulcate in anterior profile, with low median fold composed of three subequal costae; toward umbo right costa of the three merges with middle costa and near beak it merges with left costa to form a single one at umbo; sides of valve flaring, with a short costa on each side between lateral margin and median fold.

Measurements: Holotype, length, 20 mm. plus 1 or 2 mm. broken away; width, 11 mm.; hinge width, 3.8 mm.; length of dorsal valve, 8 mm.; thickness. 7 mm.

Holotype: U. S. Nat. Mus. 91882.

Horizon and locality.—Near middle of St. Clair limestone, Searcy Mine, 9 miles north-northeast of Batesville, Arkansas, associated with *O. mesleri.*

Genus STREPTIS Davidson, 1881

Streptis DAVIDSON, *1881*, Geol. Mag., dec. 2, vol. 8, p. 150, pl. 5, fig. 13. For other references see Bassler, U. S. Nat. Mus., Bull. 92, p. 1205, 1915.

This genus was proposed to receive unsymmetrical, imbricate triplesiids. The genotype, *S. grayii* Davidson, is a small species with a curved sulcus on both valves and one side of the valve twisted in relation to the opposite side. The ornamentation consists of strong lamellae, on which are superimposed fine radial costellae. Shells of a given species in this genus are not all twisted in the same manner—in *S. grayii* (Pl. 50, figs. 1, 2, 6, 7) the right side of some specimens is twisted with respect to the left, in others the reverse is true. Some undoubted species in this genus, such as *S. monilifera altosinuata* Holtedahl (Pl. 50, fig. 10), are perfectly symmetrical, with a normal fold and sulcus. These resemble *Cliftonia* (*Cliftonia*), but can be separated by the ornamentation—the lamellae of *Cliftonia* (*Cliftonia*) are not broad frills, such as those seen in some species of *Atrypa* and those shown here in *S. incompta* Ulrich and Cooper. In addition, *Streptis* has usually a finer radial ornamentation superimposed on the frills.

So far as known, *Streptis* is wholly confined to the Early and Medial Silurian and possibly the latest Ordovician. The two oldest species, *S. monilifera* McCoy and our *S. incompta*, are found in Ireland and Estonia, respectively, in formations that the senior author classes as late Richmond and post-Ordovician. It is a widespread but usually rare genus. In North America it is known from Alaska and from Arkansas.

STREPTIS GLOMERATA Ulrich and Cooper, n. sp.

Plate 50, figures 4, 5, 9, 31. Text-figure 1*b*

Streptis grayii THOMAS (not Davidson), *1928*, Denison Univ. Sci. Lab., Jour., vol. 23, p. 139, pl. 36, fig. 12.

Shell small, wider than long, subelliptical in outline, subequally biconvex unsymmetrical, bisulcate, bilobate; sulci curved. Ventral beak sharp, incurved; interarea moderately long; sulcus submedian, gently curved anterolaterally (to the observer's left, when view from exterior); apical foramen as in other members of family; deltidium flat. Dorsal valve with an inflated umbo and incurved, blunt beak; interarea obsolete. Surface ornamented by 8 or 10 concentric lamellae, in the largest specimens produced into frills of considerable length; in addition a costellation on the body of the shell, more prominent on the frills (Pl. 50, fig. 9); usually, although not always, ornamentation more distinct or better developed on elevated lobe.

Variations: In the holotype of *S. glomerata* the right side of the shell is elevated above the left (when viewed from the front with the ventral valve down). A few specimens show the reverse twist, the left side elevated above the right. Since this variation is shown also in at least two other species, *S. grayii* from England and our *S. incompta* from Estonia, it cannot be regarded as a specific character. Some St. Clair specimens

show practically no twisting; two ventral valves have a nearly straight sulcus, and a dorsal valve (Pl. 50, fig. 4) has a straight, strongly rounded fold.

Measurements: Holotype, 2.5 mm. long, 3.5 mm. wide, 1.7 mm. thick. Paratype 1, 4.5 mm. long, 6 mm. wide.

Types: Holotype, U. S. Nat. Mus. 91892; paratype 1, U. S. Nat. Mus. 91893; other paratypes, U. S. Nat. Mus. 91894–91895.

Horizon and locality.—St. Clair limestone, Searcy Mine, 9 miles north-northeast of Batesville; Cason Mine, 3 miles north-northeast of Batesville; Tomahawk Creek; 6 miles east of St. Joe; 1 mile west of Gilbert; 2 miles south of Guion; Providence; all in northern Arkansas.

Discussion.—This species has been referred to *S. grayi*, but differs in its smaller size, more convex valves, more narrow sulci, and relatively more numerous concentric lamellae.

STREPTIS INCOMPTA Ulrich and Cooper, n. sp.

Plate 50, figures 13, 25–27, 29, 30, 33–35

Shell small, elliptical in outline; unequally biconvex, the dorsal valve the more convex; hinge-line a little less than greatest width of the valves; cardinal extremities rounded, lateral margins strongly rounded, anterior margin subtruncate; anterior commissure uniplicate, frequently unsymmetrical. Surface multicostellate, provided with six or seven alate lamellae that may extend as much as 3 mm. from shell margin; costellae cover body of shell and wings, prolonged into spines at ends; whole surface crossed by fine, elevated concentric lines. In all of our specimens, only latest lamella preserved; bases of others appear as prominent concentric ridges. Ventral valve provided with shallow sulcus that originates near middle of valve; sulcus may be curved and either half of shell depressed in relation to other half; lateral slopes convex; beak small, acutely pointed; interarea short, slightly curved. Dorsal valve with low, rounded fold, originating near center of valve; lateral slopes strongly convex; beak obtuse, umbo swollen. Dental plates short, widely divergent; cardinal process long for such a small shell, prongs of fork diverge at 30°.

Measurements: Length and width without frill, respectively—Ventral valves, syntype 91891, 7 mm., 8 mm.; syntype *a*, 6 mm., 7 mm. Dorsal valves, syntype *c*, 5 mm., 6.5 mm. (width with frill, 12.5 mm.); syntype *e*, 4.5 mm., 6.3 mm.

Syntypes: U. S. Nat. Mus. 91891, *a–e*.

Horizon and locality.—Borkholm formation, Borkholm Schloss, Estonia.

Discussion.—This species suggests *S. monilifera* McCoy, from Ireland assigned by the senior author to the same epoch as *S. incompta*, the Richmondian, post-Ordovician. It differs in having unequally convex valves and only six or seven lamellae on the exterior instead of eight or nine, as in the Irish species.

Genus TRIPLESIA Hall, 1859

Triplesia HALL, *1859*, Paleontology New York, vol. 3, p. 522. For full synonymy see Bassler, U. S. Nat. Mus., Bull. 92, p. 1292, 1915.

Triplesia, type genus of the family, is characterized by a strong median sulcus on the ventral valve and an equally strong fold on the dorsal valve. Surface marked by concentric growth lines or fine undulations of growth; on some specimens a few radial undulations. In the description of the genus by Hall, mention is made of the presence of "fine obscure or obsolete radiating striae." There is no question about the existence of these fine lines, but they appear to be present on exfoliated specimens only and seem to be a feature of the interior, undoubtedly related to the sinuses of the mantle. Neither the interiors nor the exteriors of *Triplesia ortoni* (Meek) (Pl. 48, figs. 21, 28, 32, 34, 35) show sufficient constant differences to warrant the resurrection of Meek's genus *Dicraniscus*, which was based on this species. The fine

internal radial lines were not observed in any of the Silurian species referred to the genus *Triplesia*, but these, in themselves, would hardly constitute a valid distinction between the two genera.

TRIPLESIA ALATA Ulrich and Cooper, n. sp.

Plate 48, figure 23; plate 50, figures 11, 14, 16, 17, 20, 21, 24

Triplesia ortoni (Meek), MISER, *1922*, U. S. Geol. Survey, Bull. 734, pl. 7, figs. 1–3. Not. *T. ortoni* (Meek).

Shell large, unequally biconvex, subquadrate in outline; hinge wide; cardinal extremities drawn into blunt, flat wings. Ventral valve flatly convex; winged extensions of cardinal extremities set off by an oblique sulcus; beak short, incurved; sulcus deep, originating 2 to 3 mm. anterior to beak, defined by prominent ridges; at front the sulcus equal to nearly one-half width of shell; tongue short, rounded. Dorsal valve strongly convex, swollen; fold flatly convex, moderately elevated above body of shell, defined by lateral sulci; outside of lateral sulcus a low ridge curving to antero-lateral extremities, these ridges corresponding to ridges on each side of ventral sulcus. Surface of both valves marked by low concentric lines and growth varices.

Measurements: Syntypes, 91872, length, 22 mm.; width, 28 mm.; thickness, 17 mm. 91873, length, 15 mm.; width, 23 mm.; hinge width, 26? mm. 91873*c*, length 23 mm.; width, 34 mm.; 44 mm.

Syntypes: U. S. Nat. Mus. 91872, *a*; 91873, *a–c*; 91874.

Horizon and locality.—Brassfield formation, Cason Mine, 3 miles north-northeast of Batesville; Tomahawk Creek, 6 miles east of St. Joe, ½ to 1 mile west of Gilbert; all in Arkansas. One specimen from the Brassfield at Soldiers Home, Dayton, Ohio, in the U. S. National Museum collections has the characters of this species.

Discussion.—This species differs from *T. ortoni* Meek, with which it has been confused, in the strong development of the flattened and drawn-out cardinal extremities.

TRIPLESIA WALDRONENSIS (Miller and Dyer)

Spirifera? waldronensis MILLER and DYER, *1878*, Cincinnati Soc. Nat. Hist., Jour., vol. 1, p. 37, pl. 2, fig. 3. For complete synonymy see Bassler, U. S. Nat. Mus., Bull. 92, p. 809, 1915.

Four lots in the U. S. National Museum under the label *Mimulus waldronensis* proved to be composite, made up of orbicular specimens associated with the more familiar and typical angular species. Young specimens of both kinds preserve the particular characteristics which make the adults distinct. The orbicular specimens are separated below as *Triplesia rostellata* Ulrich and Cooper.

Hall and Clarke referred Miller and Dyer's species to the genus *Mimulus*, being misled by Barrande, who placed shells having the fold on either the dorsal or ventral valve in this genus. Thomas (4) regards the reversion of fold and sulcus as a generic character, correctly, we believe. Consequently, since *Mimulus perversus* Barrande, the genolectotype of *Mimulus*, has the fold on the ventral valve, *M. waldronensis* must be placed in another genus. Thomas places the species in *Triplesia*.

TRIPLESIA PRAECIPTA Ulrich and Cooper, n. sp.

Plate 48, figures 10, 11; plate 50, figure 3

Triplecia contrarius (Barrande) THOMAS, *1928*, Denison Univ. Sci. Lab., Jour., vol. 23, p. 136, pl. 36, fig. 10. Not *T. contrarius* (Barrande).

This new species is represented by two fairly large specimens and a considerable number of immature individuals. It differs from *T. waldronensis*, as seen at Newsom, Tennessee, in not being distorted, in having a much stronger sulcus, and more angular plications on the side of the sulcus. The young of this species resemble the young of *T. waldronensis*, but have a slightly wider sulcus.

Measurements: Syntypes, 91867*b*, 6

mm. long, 9 mm. wide; 91867, 4.5 mm. long, 6 mm. wide, 2.5 mm. thick.

Syntypes: U. S. Nat. Mus. 91867, *a*, *b*.

Horizon and locality.—Associated with *T. juvenis* Ulrich and Cooper in countless numbers at the top of the St. Clair limestone, Cason Mine, 3 miles north-northeast of Batesville, Arkansas.

TRIPLESIA ROSTELLATA Ulrich and Cooper, n. sp.

Plate 48, figures 9, 13

Shell small, sub-elliptical to suborbicular; hinge narrow, less than half width of shell; cardinal extremities obtuse. Ventral valve flatly convex: beak prominent, elongate, rather acutely pointed; sulcus shallow, not well defined in posterior one-half or one-third of shell. Dorsal valve gently convex; fold low, best defined at front half of shell; umbo swollen, protruding posteriorly beyond hinge margin; beak strongly incurved, bluntly pointed. Dental plates of ventral valve short, widely divergent.

Measurements: Holotype, 7.5 mm. long, 8.5 mm. wide, 3.5 mm. thick.

Holotype: U. S. Nat. Mus. 91868.

Horizon and locality.—Waldron shale at Newsom, Tennessee.

Discussion.—*Triplesia rostellata* differs from *T. waldronensis*, with which it is associated, in its more rounded outline, narrower profile, and more subdued development of fold and sulcus. Distortion is a not uncommon feature of *T. waldronensis* and also affects *T. rostellata*. However, in the few specimens of the latter studied the distortion is not very striking

TRIPLESIA JUVENIS Ulrich and Cooper, n. sp.

Plate 48, figures 4, 5

This species differs from *T. rostellata* in its somewhat smaller size and usually deeper sulcus. It is not unlikely that the St. Clair species is the ancestor of the younger Waldron species.

Measurements: Holotype, 5 mm. long, 5.5 mm. wide, 2.5 mm. thick.

Holotype: U. S. Nat. Mus. 91869.

Horizon and locality.—At the extreme top of the St. Clair limestone, Cason Mine, 3 miles north-northeast of Batesville, Arkansas.

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NEW BRACHIOPODS AND TRILOBITES FROM THE UPPER ORDOVICIAN OF PERCÉ, QUEBEC

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ABSTRACT

The faunal assemblages so far identified at 13 localities in the Upper Ordovician Whitehead formation of Percé, Quebec, are listed. The new brachiopods and trilobites are described; of brachiopods, 18 species in 16 genera (2 new); of trilobites, 26 species in 23 genera (2 new). Six genera new to America but known in Europe are added to those previously known. The individual assemblages associate forms that elsewhere are widely separated stratigraphically, though there is no doubt of the Late Ordovician age of the formation, which appears to be most closely related to the Leptaenakalk of Europe.

As the result of individual collecting, the writers brought together large assemblages of fossils from the Whitehead formation exposed in the vicinity of Percé village, Gaspé Peninsula, Quebec. Recognizing that each collection contained many fine new species, the writers decided to combine the descriptions. The present paper includes the discussion of the brachiopods and trilobites; the following papers by Rudolf Ruedemann and A. F. Foerste (pp. 373–387), those of the graptolites and cephalopods.

The species described in the three papers and those previously described by Cooper (1) do not constitute the entire fauna of the Whitehead formation, for many species of corals, bryozoans, brachiopods, ostracodes, and other fossils are still to be described. Fine species of the brachiopod genera *Rafinesquina*, *Strophomena*, *Sowerbyella*, *Orthis*, *Schizophorella?*, and *Nicolella?* were noted in the collections, but the specimens available are too fragmentary or too poorly preserved to warrant description. Trilobites of species and genera not yet described or listed from Percé are indicated by a number of fragments. These various forms give promise of more new things to come from this interesting formation.

C. H. Kindle has recently published (2) a map showing most of the localities mentioned in this paper.

Acknowledgments.—The writers thank Dr. B. F. Howell and Dr. C. E. Resser for supplying a description of their new agnostid genus *Sphaeragnostus*, Dr. Rudolf Ruedemann for his discussion of the graptolites, and Dr. A. F. Foerste for his discussion of the cephalopods.

The paper is published with the permission of the Secretary of the Smithsonian Institution. The manuscript was received by the editor July 10, 1935.

RELATIONS OF THE FAUNA

The new species herein described tend to emphasize the European affinities of the Whitehead formation. In Cooper's earlier work on the fauna (1) two genera, *Cyclopyge* and *Holotrachelus*, new to North America were described. The present paper adds several more such genera: *Porambonites* (*Isorhynchus*), *Kullervo*, *Symphysops*, and *Pharostoma*. Two new genera instituted in this paper have been known in Europe under other names: *Phylacops* is represented by "*Aeglina*" *mirabilis* Forbes and *Sphaeragnostus* by "*Agnostus*" *similaris* Barrande.

The known species of fossils from the Whitehead formation make a contradictory assemblage. There are associated, often on the same slab, genera usually found in widely separated strata. *Bilobites*, for example, is associated with the Richmond bryozoan *Sceptropora* and other types of bryozoans more commonly seen in formations of Black River or Trenton age. Such anomalies are seen as the genera *Remopleurides* and *Portlockia*, and the rare brachiopod *Brachymimulus*, previously known in North America only in the Middle Silurian St. Clair limestone of Arkansas. Ruedemann's close comparison of *Marsipograptus percensis* (p. 385) with a Chazyan species emphasizes further the peculiarity of the fauna. The assemblage of genera is unique in North America, but many similar species are well known in Europe in the Leptaenakalk, the Keisley limestone, and other Upper Ordovician strata.

Although the European equivalents of the Whitehead formation are well known, it seems impossible to correlate the formation satisfactorily in North America. Correlation with the beds of Richmond age in Anticosti has been suggested, but the exceedingly small number of unequivocally identical species in the two areas militates against close and accurate comparison. The discovery of quartz pebble conglomerates at the base of the Whitehead formation argues against the thesis that the Percé sediments represent a deep-water facies of the Anticosti sequence deposited south of the island. In the correlation of the Whitehead formation the possibilities of thrusting from the southeast should not be overlooked. At present too little is known of the structure of Gaspé to permit a satisfactory explanation of the dissimilarity between the Whitehead and Anticosti faunas.

REGISTER OF LOCALITIES WITH THEIR KNOWN SPECIES

1. Coarsely crystalline (crinoidal) limestone along the Priest's Road, about 2 miles west of Percé and half a mile east of the junction with the main highway.

Bilobites indentus, Brachymimulus aculeatus, B. triplicatus, Christiania dubia, Cliftonia (*Oxoplecia*) *costata, C.* (*O.*) *platystrophoides, Cyclospira glansfagea, Diambonia septata, Holtedahlina sulcata parva, Kullervo pyramidata?, Platystrophia inferaplicata, Plectatrypa gaspéënsis, Porambonites canadensis, Ptychoglyptus bellarugosus, Ptychopleurella sublamellosa, Rhynchotrema plicata, Sowerbyella gigantea, Triplesia biplicata, T. uniplicata.*

Achatella sp., *Calymene consimilis, Calyptaulax compressa, Ceraurinus elongatus, Ceraurus binodosus, C.* sp. 1, *Cheirurus percensis, Cybele* sp., *Cyclopyge kindlei, C. insolens, Encrinurus percëënsis, Gerasaphes similaris, Illaenus percëënsis, Lonchodomas longirostris, Otarion minima, Phaethonides bellus, Pharo-*

stoma rarum, Phylacops vigilans, Platylichas parvus, Proetus subornatus, P. cf. *P. convexus, Remopleurides striatus, R.* sp., *Sphaeragnostus gaspensis, Sphaerexochus bridgei, Sphaerocoryphe* sp., *Symphysops spinifera, Tretaspis clarkei, T. elevata.*

2. Talus slopes and bed-rock of shaly limestone in the Grande Coupé and on both sides of it along the sea cliffs at its mouth, 1½ miles northwest of Percé.

Marsipograptus percensis.
Halysites, Calapoecia, Streptelasma.
Nyctopora.
Christiania dubia, Cliftonia (Oxoplecia) perfecta, Conotreta sp., *Diambonia septata, Holtedahlina sulcata parva, Kullervo pyramidata, Plectatrypa gaspéënsis, Ptychopleurella sublamellosa, Sowerbyella gigantea.*
Apsidoceras depressum, A. sp., *Beloitoceras* sp., *Diestoceras brevidomum, D. cooperi, D. gaspense, D. subglobosum, Donacoceras percense, Geisonoceras expansum, Metaspyroceras gaspense, M. kindlei, Neumatoceras latilineatum, N. percense, N. striatum, N.* sp., *Ooceras* sp., *Orthoceras gaspense, O. kindlei, O. percense, Schuchertoceras logani, Spyroceras liratum, S.? subglabrum.*
Calymene consimilis, Calyptaulax glabella, Cyclopyge kindlei, C. insolens, C. angustata, C. sp., *Encrinurus* sp., *Illaenus percëënsis, Lonchodomas longirostris, Otarion minima, O.* sp., *Phylacops vigilans, Remopleurides* sp., *Sphaeragnostus gaspensis, Sphaerexochus bridgei, Sphaerocoryphe* sp., *Symphysops spinifera, S.* sp., *Tretaspis clarkei.*

3. Sea cliffs on the southern flank of Mont Joli, in the village of Percé. Alternating limestone and shale layers, most fossiliferous about 75 feet south of the fault contact with the Mont Joli formation.

Cyclospira minuscula, Diambonia septata.
Calymene consimilis, Calyptaulax compressa, C. glabella, Cyclopyge kindlei, Illaenus percëënsis, Isotelus sp., Lonchodomas longirostris, Tretaspis clarkei.

4. Outcrops in the fields behind the lighthouse at Whitehead (Cap Blanc). Thinbedded limestone.

Cliftonia (Oxoplecia) costata, Cyclospira minuscula, Plectatrypa gaspéënsis.
Calymene consimilis, Illaenus percëënsis, Leonaspis parva, Eophacops primaeva.

5. Along the main highway at the sharp turn descending towards The Amphitheater, north of west of Percé. Gray sandy limestones.

Mesograptus sp.
Catazyga cartieri, Cliftonia (Oxoplecia) platystrophoides, Fardenia costatula, Leptaena sp., *Liostrophia glabra, Plectatrypa gaspéënsis, Plectorthis magna, Rafinesquina percensis, Scenidioides impressus, Strophomena* n. sp.
Calymene consimilis.

6. Talus slope of limestone at head of the first stream which reaches the sea north of Whitehead.

Halysites.
Platystrophia inferaplicata, Sowerbyella gigantea.
Hormotoma gigantea?.

7. Irishtown Road, about a quarter of a mile south of its junction with the main highway at the foot of the mountain, southwest of Percé.

Sowerbyella sp.
Ceraurus sp. 2, *Encrinurus percëënsis.*

8. Sea cliff at mouth of first stream north of Whitehead.

Platystrophia inferaplicata.
Spyroceras percense.
Amphilichas rubrus, Ceraurinus elongatus.

9. At Corner of the Beach near the church and stream.

Brachyaspis schucherti.

10. Murphy's Creek, about 3 miles west of Corner of the Beach and 100 yards upstream from a quartz-pebble conglomerate.

Holotrachelus inexpectans.

11. Portage River, in blue-gray, thick-bedded, shaly limestone, 2 or 3 miles upstream from its branching at Biscuit Creek.

Ampyx inflatus, Phylacops vigilans, Symphysops spinifera.

12. At the intersection of the 5th range line and a small tributary to Biscuit Creek near the Rameau-Malbaie township line (8 or 10 miles west of Corner of the Beach and 2 or 3 miles southwest of locality 11).

Calymene consimilis, Cheirurus percensis, Eophacops primaeva.

13. In a field 1 mile from the coast and a quarter of a mile east of Brêche à Manon Brook at the western border of Percé township.

Tretaspis elevata.

Brachiopods from the Whitehead Formation

Bilobites indentus Cooper.....Locality 1
Brachymimulus aculeatus Cooper and Kindle, n. sp..... 1
Brachymimulus triplicatus Cooper and Kindle, n. sp..... 1
Catazyga cartieri Cooper and Kindle, n. sp.....5, between 9 and 10
Christiania dubia Cooper..... 1, 2
Cliftonia (*Oxoplecia*) *costata* Cooper... 1, 4
Cliftonia (*Oxoplecia*) *perfecta* Cooper and Kindle, n. sp..... 2
Cliftonia (*Oxoplecia*) *platystrophoides* Cooper..... 1, 5
Conotreta sp..... 2
Cyclospira glansfagia Cooper and Kindle, n. sp..... 1
Cyclospira minuscula Cooper..... 3, 4
Diambonia septata (Cooper), n. gen... 1–3
Fardenia costatula Cooper and Kindle, n. sp..... 5
Holtedahlina sulcata parva Cooper..... 1, 2
Kullervo pyramidata Cooper and Kindle, n. sp..... 1?, 2
Liostrophia glabra Cooper and Kindle, n. gen. and sp..... 5
Platystrophia inferaplicata Cooper..... 1, 6, 8
Plectatrypa gaspéënsis Cooper.....1, 2, 4, 5
Plectorthis magna Cooper and Kindle, n. sp..... 5
Porambonites (*Isorhynchus*) *canadensis* Cooper and Kindle, n. sp..... 1
Ptychoglyptus bellarugosus Cooper..... 1
Ptychopleurella sublamellosa Cooper... 1, 2
Rafinesquina percensis Cooper and Kindle, n. sp..... 5
Rhynchotrema plicata Cooper and Kindle, n. sp..... 1
Scenidioides impressus Cooper and Kindle, n. sp..... 5
Sowerbyella gigantea Cooper.....1, 2, 6
Strophomena n. sp..... 5
Triplesia biplicata Cooper and Kindle, n. sp..... 1
Triplesia uniplicata Cooper and Kindle, n. sp..... 1

Trilobites from the Whitehead Formation

Achatella sp.....Locality 1
Amphilichas rubrus Cooper and Kindle, n. sp..... 8
Ampyx inflatus Cooper and Kindle, n. sp..... 11
Brachyaspis schucherti Cooper and Kindle, n. sp..... 9
Calymene consimilis Cooper.....1–5, between 9 and 10, 12
Calyptaulax compressa Cooper..... 1, 3
Calyptaulax glabella Cooper..... 2, 3
Ceraurinus elongatus Cooper..... 1, 8
Ceraurus binodosus Cooper and Kindle, n. sp..... 1
Ceraurus sp. 1..... 1
Ceraurus sp. 2..... 7
Cheirurus percensis Cooper and Kindle, n. sp..... 1, 12
Cybele sp..... 1
Cyclopyge angustata Cooper and Kindle, n. sp..... 2
Cyclopyge insolens Cooper..... 1, 2
Cyclopyge kindlei Cooper..... 1–3
Cyclopyge sp..... 2
Encrinurus percëënsis Cooper..... 1, 7
Encrinurus sp..... 2
Eophacops primaeva (Clarke)..... 4, 12
Gerasaphes similaris Cooper and Kindle, n. sp..... 1
Holotrachelus inexpectans Cooper..... 10
Illaenus percëënsis Cooper..... 1–4
Isotelus sp..... 3
Leonaspis parva Cooper..... 4
Lonchodomas longirostris Cooper.....1–3, between 10 and 11
Otarion minima Cooper..... 1, 2
Otarion sp..... 2
Phaethonides bellus Cooper and Kindle, n. sp..... 1
Pharostoma rarum Cooper and Kindle, n. sp..... 1
Phylacops vigilans Cooper and Kindle, n. gen. and sp.....1, 2, 11
Platylichas parvus Cooper and Kindle, n. sp..... 1
Proetus subornatus Cooper and Kindle, n. sp..... 1
Proetus cf. *P. convexus* Warburg..... 1
Remopleurides striatus Cooper and Kindle, n. sp..... 1
Remopleurides sp..... 1, 2
Sphaeragnostus gaspensis Cooper and Kindle, n. gen. and sp..... 1, 2
Sphaerexochus bridgei Cooper and Kindle, n. sp..... 1, 2

Sphaerocoryphe sp..... 1, 2
Symphysops spinifera Cooper and Kindle, n. sp..... 1, 2, 11
Symphysops sp..... 2
Tretaspis clarkei Cooper..... 1–3
Tretaspis elevata Cooper and Kindle, n. sp..... 1, 13

SYSTEMATIC DESCRIPTIONS

BRACHIOPODA

CONOTRETA sp.

A slightly damaged specimen about 1.5 mm. long and 1 mm. wide is conical, with an apical angle of 46°; posterior surface slightly concave; homoeodeltidium narrow, gently convex. Dorsal valve unknown.

Unfigured specimen: U. S. Nat. Mus. 91808.

Locality.—Shaly limestones of the Grande Coupé.

PLECTORTHIS MAGNA Cooper and Kindle, n. sp.

Plate 51, figures 11, 24, 33, 37

Shell large for the genus, with rather wide hinge and rounded cardinal extremities; lateral margins strongly rounded, front margin broadly rounded. Valves unequally convex, ventral valve a little deeper than the dorsal valve. Surface marked by slender, elevated costellae which increase by bifurcation and interstitial addition. Ventral valve full in the umbonal and midregions, the lateral areas gently concave; beak incurved. Dorsal valve flatly convex in the young, rather evenly, gently convex in adults; umbonal region of old shells swollen. Inside ventral valve the muscular area short, narrow, with narrow diductor impressions. In dorsal valve the supporting plates of brachiophores discrete, subparallel where they attach to the floor of the valve; cardinal process thin.

Measurements: Syntype 91825, ventral valve, length, 15.5 mm., width, 18 mm. Syntype 91825*b* dorsal valve, length 20 mm., width, 23.5? mm. Syntype 91825*c*, dorsal valve, length, 10 mm., width, 14 mm.

Syntypes: U. S. Nat. Mus. 91825,*a–e*, Nat. Mus. Canada 8855.

Locality.—Gray, sandy limestones beside the road along the descent to The Amphitheater.

Discussion.—The specimens on which this species is based are not well preserved, and all details of the interior and exterior were obtained by dissolving the exfoliated shell from the sandy matrix with weak acid. *P. magna* is the largest species of the genus yet found. *Plectorthis* is best known from the vicinity of Cincinnati, where a number of species occur in the soft shales of the Maysville division of the Cincinnatian group. The Percé species differs from all known American species in its fine ornamentation. The Cincinnatian specimens as a rule are rather coarse-ribbed, with the bifurcation of the ribs taking place near the front of the valves; in the Percé species implantation of costellae takes place on the flanks of the umbo and many of the ribs bifurcate near the middle of the valve.

The internal features of *P. magna* are mostly typical of the genus. The ventral muscular area is like that of the Cincinnatian specimens, being elliptical in outline and a little thickened around the edges. Inside the dorsal valve the lamellae are a little more erect than is usual in the Maysville specimens and the cardinal process appears to be rather rudimentary. The dorsal valve appears to be a little less typical of the genus than the ventral valve.

Not one of the species referred to *Plectorthis* by Cowper-Reed in the "*Ordovician and Silurian Brachiopoda of the Girvan District*" appears to be related to the Percé species.

SCENIDIOIDES IMPRESSUS Cooper and Kindle, n. sp.

Plate 2, figures 18, 32; text-figure 7

Rather large for the genus and resembling a small *Hesperorthis* in outline and profile. Ventral valve subpyramidal in outline, with gently convex lateral profile; in anterior profile, strongly arched; in the mid-region a rather strong rounded fold from which sides slope steeply. Dorsal valve flat or gently convex in lateral profile, concave in anterior profile; sulcus quite deep, wide at the front; cardinal extremities deflected a little ventrally, lateral areas gently convex. Inside the ventral valve a thick spondylium; in the dorsal valve a long septum. Surface marked by 24 to 30 simple costae.

Measurements: Ventral valve, 10.5 mm. long, 12 mm. wide; dorsal valve, 6 mm. long, 8 mm. wide, 9 mm. across hinge.

Syntypes: U. S. Nat. Mus. 91783,*a*.

Locality.—Sandy limestones on the roadside descending the slope to The Amphitheater.

Discussion.—In its large size this species suggests *S. greenoughi* Cowper-Reed, but the Percé species is a little more carinate and the dorsal valve has a wider sulcus. The two are large species for the genus.

PORAMBONITES (ISORHYNCHUS) CANADENSIS Cooper and Kindle, n. sp.

Plate 51, figure 5; text-figures 5, 6

None of the specimens available is good, but two of them show the characteristic ornamentation and two show the ventral interior very well. Ventral valves rather small, gently convex in lateral profile, subcircular in outline, gently convex in anterior profile; umbo full, beak incurved; gentle sulcus at front. Ornamentation of fine radial costellae with a row of small pits occupying the interspaces. One specimen, a large but damaged dorsal valve, probably belonging with the ventral valves, shows a prominent fold anterior to the beak. Ventral interior with strong, erect, thin dental plates that extend from the teeth to the floor of the valve, converging ventrally but joining the floor of the valve some distance apart.

Syntypes: U. S. Nat. Mus. 91798,*a–d*; Nat. Mus. Canada 8856.

Locality.—Crystalline limestone in lenses on south side of the Priest's Road.

Discussion.—So far as known this is the first report of an authentic *Porambonites* (*Isorhynchus*) from North America. Several North American species have been referred to this genus, but all have later been more correctly placed in other generic categories.

KULLERVO PYRAMIDATA Cooper and Kindle, n. sp.

Plate 51, figures 1–4; text-figure 10

Shell small, with very unequal valves. Ventral valve pyramidal with hinge wider than width of the valve at middle; interarea broad, long; delthyrium narrow, covered by a strongly convex deltidium; apical foramen large and, in two specimens, surrounded by an elevated, distorted lip; in profile very gently convex; cardinal extremities separated from body of shell as ears by prominent depressions, the ears carrying concentric ornamentation only. Dorsal valve flatly convex in profile, with cardinal extremities drawn out. Surface, as shown by the ventral valves, covered by costellae, crossed by heavy concentric lines of almost as great strength as the costellae; crossing of radial and concentric ornamentation gives the surface a strongly pitted appearance. Spondylium typical of the genus as described by Öpik; the small chamber at front end of spondylium, which characterizes the genus, is present, as shown in the section (text-fig. 10). In the dorsal valve adductor tracks elongate and oblique; cardinal process itself simple, united with the chilidium.

Measurements: Syntype 87434, ventral valve, 9 mm. long, 13.5 mm. wide. Syntype 8857, ventral valve, 11 mm. long, 15 mm. wide. Syntype 87434*a*, 7 mm. long, 14 mm. wide.

Syntypes: U. S. Nat. Mus. 87434,*a–c*; 87429. Nat. Mus. Canada 8857.

Localities.—Rare at the Grande Coupé; one specimen (87429) from the Priest's Road.

Discussion.—*K. pyramidata* strongly

EXPLANATION OF PLATE 51

U.S.N.M., U. S. National Museum; N.M.C., National Museum of Canada.

FIGS. *1–4—Kullervo pyramidata* Cooper and Kindle, n. sp., syntypes, ×1½, Grande Coupé. *1, 4*, External and apical views of ventral valve, U.S.N.M. 87434. *2*, Side view of ventral valve showing the strongly elevated deltidium, N.M.C. 8857. *3*, Dorsal interior showing the cardinal process and elongate adductor impressions, U.S.N.M. 87434*a*. (p. 353)

5—Porambonites (*Isorhynchus*) *canadensis* Cooper and Kindle, n. sp., exterior of ventral valve showing pores indistinctly, ×1; syntype, U.S.N.M. 91798; Priest's Road. (p. 353)

6—Diambonia septata (Cooper), dorsal interior of an exceptionally well preserved specimen, ×2; hypotype, U.S.N.M. 91807; Grande Coupé. (p. 356)

7, 23—Brachymimulus triplicatus Cooper and Kindle, n. sp., syntypes, ×2, Priest's Road. *7*, Slightly distorted ventral valve, U.S.N.M. 91784. *23*, Dorsal valve, U.S.N.M. 91784*a*. (p. 357)

8—Brachymimulus aculeatus Cooper and Kindle, n. sp., ventral valve, ×2; holotype, U.S.N.M. 87423; Priest's Road. (p. 358)

9, 10—Diambonia gibbosa (Winchell and Schuchert), hypotypes, ×2. *9*, Internal impression of the ventral valve showing the quadrate muscular area and the stout medium septum; U.S.N.M. 45431; Trenton (*Fusispira* bed), Mantorville, Minnesota. *10*, Dorsal interior showing the diaphragm; U.S.N.M. 45299; Trenton (*Fusispira* bed), Kapp's Run, 4 miles south of Cannon Falls, Minnesota. (p. 356)

11, 24, 33, 37—Plectorthis magna Cooper and Kindle, n. sp., syntypes, The Amphitheater. *11, 37*, Plasticine replicas of dorsal exterior showing ornamentation, ×1; U.S.N.M. 91825*a,b*. *24, 33*, Ventral valve, ×1½, after and before treatment with acid to bring out shape of muscular area; original surface exfoliated; U.S.N.M. 91825. (p. 352)

12, 13—Leangella triangularis (Holtedahl), hypotypes, ×2, Lower Llandovery (stage with *Stricklandia lens*), Asker, Oslo, Norway. *12*, Internal impression of ventral valve showing the muscular impressions and absence of median septum, U.S.N.M. 91828. *13*, Wax replica from an impression of the dorsal interior, U.S.N.M. 91828*a* (p. 356)

14, 16, 17, 22—Triplesia biplicata Cooper and Kindle, n. sp., syntypes, ×1, Priest's Road. *14, 16, 22*, Front, side, and posterior views of dorsal valve, U.S.N.M. 91793*a*. *17*, An imperfect ventral valve, U.S.N.M. 91793. (p. 358)

15, 19–21—Triplesia uniplicata Cooper and Kindle, n. sp., syntypes, ×1, Priest's Road. *15, 19, 20*, Posterior, side, and front views of dorsal valve; cardinal process imperfectly shown; U.S.N.M. 91787*a*. *21*, Imperfect ventral valve, U.S.N.M. 91787. (p. 358)

18, 32—Scenidioides impressus Cooper and Kindle, n. sp., syntypes, ×2, The Amphitheater. *18*, An exfoliated ventral valve; *32*, dorsal valve; U.S.N.M. 91783*a*. (p. 353)

25–29—Cliftonia (*Oxoplecia*) *perfecta* Cooper and Kindle, dorsal, anterior, side, posterior, and ventral views, ×1, of holotype, N.M.C. 8864; Grande Coupé. (p. 358)

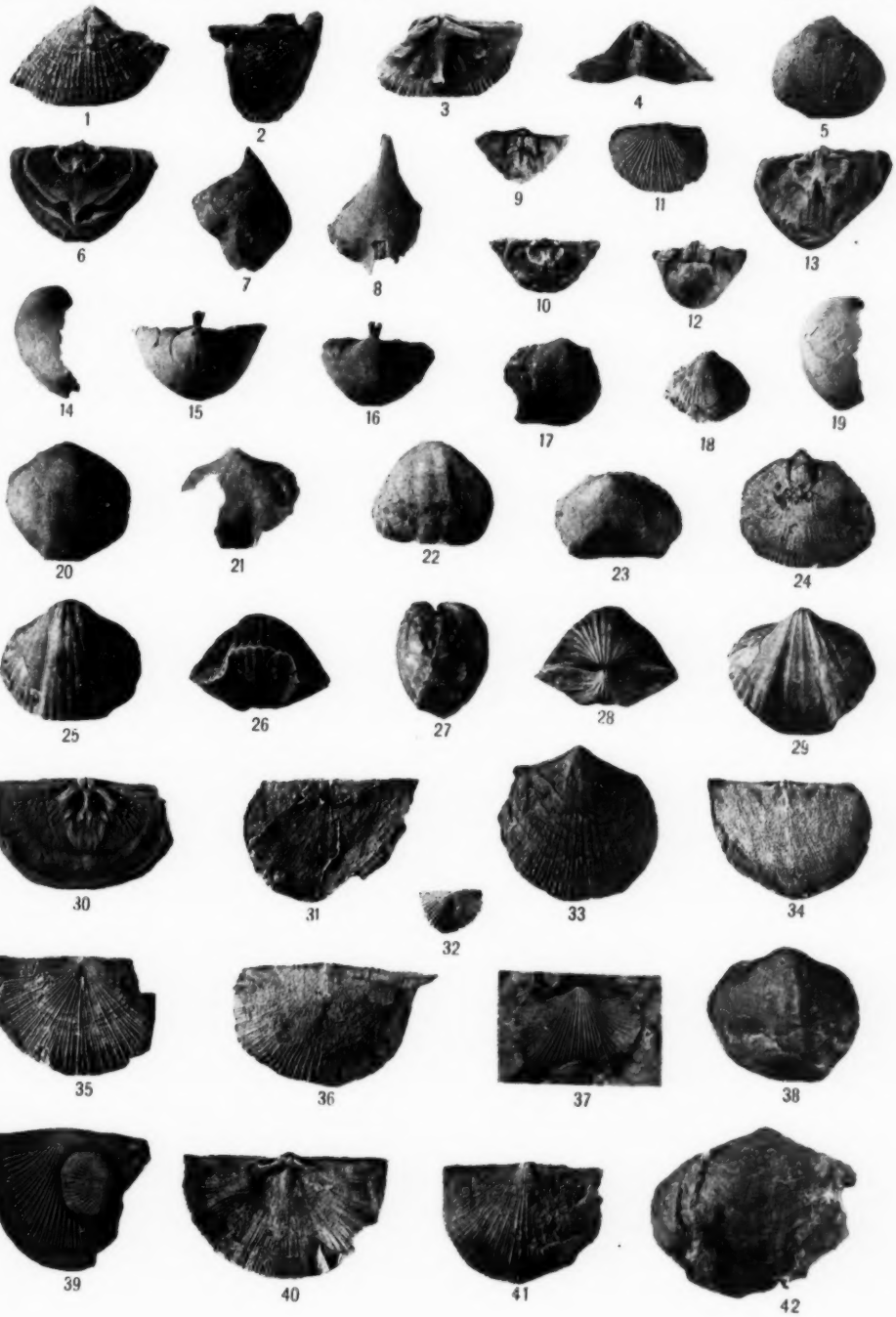
30—Holtedahlina sulcata parva Cooper, dorsal interior showing the cardinal process and other details, ×2; hypotype, U.S.N.M. 91782; Grande Coupé. (p. 357)

31, 34, 36, 41—Rafinesquina percensis Cooper and Kindle, n. sp., syntypes, ×2, The Amphitheater. *31, 34*, Wax replicas of the exterior and interior of a dorsal valve, U.S.N.M. 91815*a*. *36*, Ventral exterior showing the narrowly attenuated cardinal extremity, N.M.C. 8859. *41*, Ventral exterior showing the ornamentation well, U.S.N.M. 91815. (p. 356)

35, 40—Strophomena n. sp., external and internal views, ×1, of dorsal valve; U.S.N.M 91853*a*; The Amphitheater. (p. 357)

38, 42—Liostrophia glabra Cooper and Kindle, n. gen. and sp., syntypes, ×1, The Amphitheater. *38*, Partly exfoliated dorsal valve, U.S.N.M. 91816*a*. *42*, Partly exfoliated large ventral valve, U.S.N.M. 91816. (p. 355)

39—Fardenia costatula Cooper and Kindle, n. sp., wax replica of dorsal valve showing the strong costellae, ×1; syntype, U.S.N.M. 91826; The Amphitheater. (p. 357)



Cooper and Kindle, Ordovician Brachiopods

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resembles *K. complectens* (Wiman), the type of the genus, but differs in the possesion of a narrower deltidium, a smaller foramen, a weaker sulcus on the ventral valve, and proportionately greater length

LIOSTROPHIA Cooper and Kindle, n. gen.

Externally like *Syntrophia*, with a strong median sulcus on the ventral valve and broad median fold on the dorsal valve. Surface without other ornamentation than concentric growth-lines. Interior of ventral valve provided with a spondylium duplex. In the dorsal valve a long cruralium and alate processes just anterior to the brachial supports, as in *Anastrophia* and allies. Shell impunctate.

Genotype: *Liostrophia glabra* Cooper and Kindle.

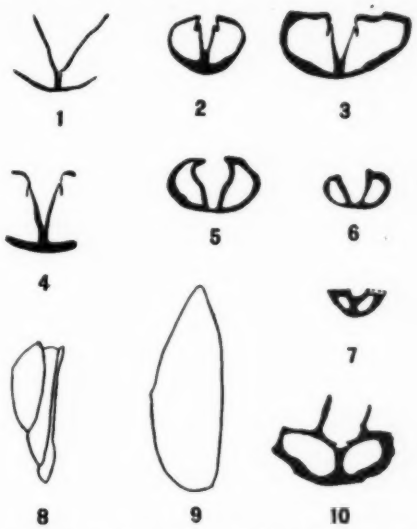
Remarks.—In structure this genus proves to be a smooth *Anastrophia*. The only brachiopod known to the authors which might prove ultimately to be closely related is *Branconia* Gagel. Too little is known of this rare genus, however, and the description is too indefinite to permit close comparison.

LIOSTROPHIA GLABRA Cooper and Kindle, n. sp.

Plate 51, figures 38, 42; text-figures 1–4

Shell large, with narrow hinge; unequally biconvex; dorsal valve deeper than ventral. Ventral valve gently convex with shallow sulcus originating about one-fourth the length of the valve from the beak, widening rapidly to occupy about one-half the width of the valve at the anterior; sulcus bounded by low folds which die out at about the middle of the valve; umbo gently convex; beak a little incurved. Dorsal valve a little more convex than ventral valve, marked longitudinally by a low, gently rounded fold; lateral slopes flatly convex and moderately steep. Ventral septum extends for about one-third the length of valve; dorsal septum extends to middle of valve.

Measurements: Syntype 91816, ventral valve, 30? mm. long, 20 to 23? mm. wide. Syntype 91816*a*, dorsal valve, 18 mm. long, 20.5 mm. wide.



FIGS. *1–4*—*Liostrophia glabra* Cooper and Kindle, n. sp. syntypes, U. S. Nat. Mus. 91816*b,c;* The Amphitheater. *1*, Section through beak of ventral valve, showing the spondylium duplex, ×3 approximately. *2–4*, Sections of the dorsal valve, 1.25, 2.25, and 3 mm., respectively, from the beak, ×3. (p. 355)

5, 6—*Porambonites* (*Isorhynchus*) *canadensis* Cooper and Kindle, n. sp., sections of the beaks of two ventral valves, ×1½ and ×2, respectively; syntypes, U. S. Nat. Mus. 91798*a,b;* Priest's Road. (p. 353)

7—*Scenidioides impressus* Cooper and Kindle, n. sp., section not far from the tip of the beak of the ventral valve, ×4 approximately; syntype, U. S. Nat. Mus. 91783; Grande Coupé. (p. 353)

8, 9—*Sphaeragnostus gaspensis* Cooper and Kindle, n. sp., profiles of the pygidium, ×5, and the cephalon, ×4; syntypes, U. S. Nat. Mus. 91810, 91802; Grande Coupé. (p. 361)

10—*Kullervo pyramidata* Cooper and Kindle, n. sp., section of the beak of a small ventral valve through the foramen, ×2 approximately, to show the highly elevated sides of the foramen; syntype, U. S. Nat. Mus. 87434*b;* Grande Coupé. (p. 353)

Syntypes: U. S. Nat. Mus. 91816,*a–d;* Nat. Mus. Canada 8858.

Locality.—Associated with *Catazyga*

cartieri in hard sandy limestones by the side of the road down the steep descent to The Amphitheater.

Discussion.—The only described species known to the writers that suggests *L. glabra* is *Branconia borussica* Gagel, which is known to have a median septum in each valve. *L. glabra* differs from it in having a less strongly arched dorsal valve and in lacking a strong depression in the fold of the dorsal valve.

DIAMBONIA Cooper and Kindle, n. gen.

Shell small, externally resembling *Leptelloidea*. Ventral interior with deeply impressed, quadrangular muscular area; diductor impressions large, widest at posterior, tapering antero-laterally; adductor impressions small, situated at posterior part of muscular field; diductor impressions separated by low septum; in front of the muscular field a rather long, strong, median septum that may extend nearly to middle of valve. Dorsal interior like that of *Leangella* (Pl. 51, figs. 12, 13), with small diaphragm located at posterior of shell, surrounded by a large triangular field; brachial processes small, short, widely divergent; cardinal process, viewed from posterior, a strong carinate ridge flanked on both sides by chilidial plates; on the inside of the shell cardinal process appears as a boss, triangular in section.

Genotype: *Plectambonites gibbosa* (Winchell and Schuchert), *Geol. Survey Minnesota, Final Rept.*, vol. 3, pt. 1, p. 416, pl. 32, figs. 13–17, 1895. Hypotypes: U. S. Nat. Mus. 45431, 45299 (see Pl. 51, figs. 9, 10).

Discussion.—*Diambonia* is closest to *Leangella* Öpik, but differs in the possession of a strong median septum in the ventral valve. It appears to be confined to the Ordovician. Jones has described a number of species of *Leptelloidea*, three of which have been assigned to *Leangella* by Öpik, but Jones figures no specimen having the long median septum that characterizes the American species here referred to *Diambonia*. However, two specimens in the U. S. National Museum (cat. no. 24038), from the Bala of Glyn Ceriog, show the same characters of the ventral valve as *D. gibbosa*, the genotype.

DIAMBONIA SEPTATA (Cooper)

Plate 51, figure 6

Leptelloidea septata COOPER, *1930*, Am. Jour. Sci., ser. 5, vol. 20, p. 272, pl. 1, figs. 9–13.

The ventral valve of this species possesses the strong median septum characteristic of the new genus. An exceptionally fine dorsal interior is figured.

Hypotype: U. S. Nat. Mus. 91807.

Localities—Grande Coupé; Priest's Road; south flank of Mont Joli.

RAFINESQUINA PERCENSIS Cooper and Kindle, n. sp.

Plate 51, figures 31, 34, 36, 41

A small species rarely attaining a width of more than half an inch; cardinal extremities acutely pointed, front margin broadly rounded; lateral profile rather strongly convex, with the greatest convexity in front of the middle. Surface of ventral valve covered by fine costellae of unequal size; at front of valve 3 of larger costellae in space of 1 mm. and between each of these 2 or 3 finer costellae; one costella, stronger than the others, extends from beak to front margin, along center of valve. Dorsal valve gently concavė at posterior and middle but strongly geniculated at front; costellae of more equal size than those of ventral valve; 6 to 8 costellae in space of 1 mm. at front of valve. Shell apparently too thin to preserve traces of ventral muscle scars; in dorsal valve cardinal process very small, and scarcely any development of a median ridge, as is usual in *Rafinesquina*, *Playfairia*, and allies.

Measurements: Ventral valves, syntype 91815, 8 mm. long, 10 mm. wide, 12? mm. across hinge; syntype 8859, 8 mm. long, 11.5 mm. wide, 14 mm. across hinge.

Syntypes: U. S. Nat. Mus. 91815,*a*; Nat. Mus. Canada 8859.

Locality.—Abundant in sandy layers along the road descending to The Amphitheater. The surfaces of the slabs are often crowded with dissociated valves.

Discussion.—*R. percensis* superficially suggests *Leptaena? nitens* (Billings), from the English Head formation of Anticosti. In reality it differs from *L.? nitens* in important details of the exterior and the interior—in outline, the lateral margins being more oblique and the cardinal extremities more pointed; in profile, the region posterior to the middle of the valve being more convex; in the interior of the dorsal valve, *L.? nitens* having a rather strong cardinal process and a prominent median septum extending nearly to the middle of the valve.

STROPHOMENA n. sp.
Plate 51, figures 35, 40

Shell about two-thirds as long as wide. Dorsal valve in profile very gently concave in the vicinity of the beak, gently convex in front half; in front of beak a shallow sulcus which is lost towards front of valve. Surface marked by both strong and fine costellae; 5 costellae in the space of 5 mm. at front of shell; between strong costellae 1 to 3 fine costellae; whole surface covered by strong, elevated concentric lines.

Figured specimens: U. S. Nat. Mus. 91853,*a*.

Locality.—By side of road leading down to The Amphitheater, on west side of Mt. Ste. Anne.

HOLTEDAHLINA SULCATA PARVA Cooper
Plate 51, figure 30

Holtedahlina sulcata parva COOPER, *1930*, Am. Jour. Sci., ser. 5, vol. 20, p. 270, pl. 1, figs. 6–8.

A fine dorsal valve of this species, showing the interior, was discovered at the Grande Coupé and is here illustrated.

Hypotype: U. S. Nat. Mus. 91782.

FARDENIA COSTATULA Cooper and Kindle, n. sp.
Plate 51, figure 39

A large species with gently convex valves. Dorsal valve a little more convex than ventral valve, with gently convex lateral margins, broadly rounded anterior margins; mid-region of valve very gently swollen; region of valve between the swollen middle portion and cardinal extremities gently concave; umbo a little swollen, bearing a faint depression a little anterior to the beak. Ventral valve gently convex at posterior, gently concave towards the front; inside this valve, short, flaring dental plates. Ornamentation of strong, rounded, distant costellae which increase by implantation at posterior of the shell but by bifurcation near front.

Measurements: Dorsal valve, 20 mm. long, 22 mm. wide, 26 mm. across hinge.

Syntypes: U. S. Nat. Mus. 91826,*a*,*b*; Nat. Mus. Canada 8860.

Locality.—Sandy layers by side of road descending to The Amphitheater.

Discussion.—This species has been assigned to *Fardenia* on the basis of its ornamentation and the character of the dental lamellae of the ventral valve. No Ordovician *Strophomena* known to the writers has the type of ornamentation exhibited by this species. *F. costatula* has been listed as *Schellwienella* cf. *S. gamachiana* Twenhofel, but differs in its proportions, being a much narrower and longer shell than *S. gamachiana* and showing a wider hinge and differing ornamentation.

BRACHYMIMULUS TRIPLICATUS Cooper and Kindle, n. sp.
Plate 51, figures 7, 23

Subtriangular in outline, with long ventral and short dorsal valve. Ventral valve trilobed at front, acutely pointed at posterior; beak abruptly tapered to a sharp point; fold originating in front of middle of valve, strongly elevated; lateral areas forming convex lobes with rounded margins on each side of fold. Dorsal valve transversely subelliptical in outline, with rather narrowly rounded lateral margins; umbo swollen, shell evenly convex to middle of valve; in front of middle the valve abruptly bent antero-ventrally to form a wide but

shallow sulcus; plications bounding the sulcus widely divergent, subangular; lateral slopes gently convex, moderately steep.

Measurements: Syntypes; ventral valve, 9 mm. long, 6.5 mm. wide; dorsal valve, 5.5 mm. long, 8 mm. wide.

Syntypes: U. S. Nat. Mus. 91784*a;* Nat. Mus. Canada 8861.

Locality.—Crystalline limestones along the Priest's Road.

Discussion.—The only other place on the North American continent where this genus is known is in Arkansas, where it is abundant in the lower part of the St. Claire limestone. The genus is very rare at Percé, only four specimens having been found. This species suggests *B. apiculatus* Salter and Forbes from Chair of Kildare, but has a much sharper and longer beak.

BRACHYMIMULUS ACULEATUS Cooper and Kindle, n. sp.

Plate 51, figure 8

This species occurs with the preceding and is distinguished by its much longer beak, less elevated fold on the ventral valve and the more gently convex lateral lobes.

Measurements: Ventral valve, 9.5 mm. long, 8? mm. wide.

Holotype: U. S. Nat. Mus. 87423.

Locality.—Crystalline limestones along the Priest's Road.

TRIPLESIA UNIPLICATA Cooper and Kindle, n. sp.

Plate 51, figures 15, 19–21

A rotund, gibbous species, subcircular in outline. Dorsal valve about twice as deep as ventral valve; lateral margins strongly rounded; width a little more than twice width of hinge. So far as can be observed surface is smooth except for fine concentric lines of growth. Ventral umbo convex for about one-third the length of the valve from beak, but anterior to this portion deeply depressed to form a wide, flat sulcus; on each side of sulcus at front, steeply elevated plications; lateral slopes gently convex, steep; beak a little incurved. Dorsal valve strongly convex in profile, most convex in the umbonal region, which is swollen; beak small; fold low, flat, originating about 5 mm. in front of beak and rising gently towards front of valve; lateral areas swollen. Cardinal process small, delicate, about 2 mm. long.

Measurements: Ventral valve, 14? mm. long, 17? mm. wide, 4 mm. thick. Dorsal valve, 16 mm. long, 19 mm. wide.

Syntypes: U. S. Nat. Mus. 91787,*a;* Nat. Mus. Canada 8862.

Locality.—Crystalline limestones on southwest side of Priest's Road.

TRIPLESIA BIPLICATA Cooper and Kindle, n. sp.

Plate 51, figures 14, 16, 17, 22

This species resembles the preceding but differs in having a more convex ventral valve with gentler, more rounded sulcus without abruptly elevated sides. Dorsal valve much more strongly arched than in *T. uniplicata;* the gentle fold carries a rather prominent sulcus extending from umbo to front margin.

Measurements: Ventral valve, 11.5? mm. long, 13? mm. wide, 2.5 mm. thick. Dorsal valve, 13 mm. long, 16.5 mm. wide, 9 mm. thick.

Syntypes: U. S. Nat. Mus. 91783,*a;* Nat. Mus. Canada 8863.

Locality.—Crystalline limestones on the southwest side of the Priest's Road.

CLIFTONIA (OXOPLECIA) PERFECTA Cooper and Kindle, n. sp.

Plate 51, figures 25–29

This species is of about the usual size for the genus, with deep, wide sulcus in ventral valve and broad, flat fold in dorsal valve. Ventral valve moderately convex with strongly incurved beak; sulcus originating at 2½ to 3 mm. from the beak, widening rapidly and producing a rather long tongue at front of valve; beak smooth, umbo swollen, convex. At the beak a low fold which reverts to a sulcus, the fold formed by two

costellae which merge into the general convexity of the beak; at about point where fold reverts to form a sulcus additional costellae intercalated, 6 appearing at the front margin; ribs bounding the sulcus strong; those of the lateral slopes increasing by bifurcation near the beak. Dorsal valve strongly convex, with swollen umbo and strongly incurved beak; at posterior a faint sulcus occupied by three costellae, that reverts to form a fold occupied by 7 costellae; lateral slopes gently convex, steep.

Measurements: Holotype, 16.3 mm. long, 20 mm. wide, 13.5 mm. thick.

Holotype: Nat. Mus. Canada 8864.

Locality.—Grande Coupé.

Discussion.—This is a much larger and less rotund species than the *C.* (*O.*) *costata* Cooper and is proportionately narrower than the *C.* (*O.*) *platystrophoides* Cooper.

RHYNCHOTREMA PLICATA Cooper and Kindle, n. sp.

Plate 52, figures 2, 3, 5, 6

Small, wider than long, unequally biconvex, with low fold on dorsal valve defined in the front half of shell only. Surface marked by 12 to 16 subangular costae; 4 costae occupying the sulcus, 5 marking the fold.

Measurements: Holotype, 12 mm. long, 13.5 mm. wide, 7 mm. thick.

Types: Holotype, U. S. Nat. Mus. 91785. Paratypes, U. S. Nat. Mus. 91785*a;* Nat. Mus. Canada 8865.

Locality.—Lenses of crystalline limestone on southwest side of Priest's Road.

Discussion.—This species has been recorded as *R. janeum* (Billings), but it is a much wider shell with a wider sulcus and lower fold. In addition to these differences the Percé species has four costae in the sulcus and five on the fold. *R. janeum* has only three costae in the sulcus.

CYCLOSPIRA GLANSFAGEA Cooper and Kindle, n. sp.

Plate 52, figures 1, 4, 7

Shell about usual size for genus, longitudinally subelliptical. Ventral valve strongly convex, very deep; dorsal valve gently convex in profile, shallow. Umbonal region of ventral valve narrow, elevated; the narrow umbo extended forward as a low fold, from sides of which flanks of shell descend steeply to margins; fold low, occupied by a shallow sulcus which originates a little posterior to middle of valve; center of sulcus in turn occupied by a narrow elevated costella in region from middle of valve to front margin; beak ridges of ventral valve strong, sharp, forming posterior margin and extending with a deep anterior curve to rounded cardinal extremities. Anterior profile of dorsal valve gently concave; the wide sulcus occupied from beak to anterior margin by a low rounded fold which widens towards front; a faint, narrow, depressed line present on the fold near front of shell; flanks of dorsal valve gently convex.

Measurements: Holotype, 6.3 mm. long, 6.3 mm. wide, 4.5 mm. thick. Paratype, 6.5 mm. long, 6.5 mm. wide, 4.3 mm. thick.

Types: Holotype, U. S. Nat. Mus. 91800. Paratypes, U. S. Nat. Mus. 91800*a;* Nat. Mus. Canada 8866.

Locality.—Rare in the crystalline limestone lenses on the southwest side of the Priest's Road.

Discussion.—This species suggests *C. bisulcata* (Emmons) but differs in being a smaller shell with a flatter dorsal valve which has a somewhat deeper sulcus but a much less prominent fold within the sulcus.

CATAZYGA CARTIERI Cooper and Kindle, n. sp.

Plate 52, figures 8–13, 18

Rather large, subcircular in outline, subequally biconvex; ventral valve having a little greater depth than dorsal valve. Anterior commissure gently uniplicate. Surface marked by 40 to 50 narrow, rounded costellae separated by interspaces narrower than the costellae; 8 to 9 costellae in 5 mm. at front margin of a large individual. Ventral valve

gently convex at front and middle but strongly convex at posterior; umbo narrowly elevated, extending forward as a low fold to about middle of valve; from middle, or anterior to middle, of valve a shallow depression extending as a sulcus to front margin; in mid and front region of shell lateral areas flat or gently convex, sloping steeply; beak strongly incurved, beak ridges strong. Dorsal valve rather gently, evenly convex; umbonal region gently sulcate, but sulcus dies out at about middle of valve, where it is evenly convex or slightly elevated to form a faint fold.

Measurements: Holotype, 15 mm. long, 13.8 mm. wide, 8.8 mm. thick. Paratype 8867, 16.3 mm. long, 15 mm. wide, 10 mm. thick; paratype 91876*a*, 10 mm. long, 9.3 mm. wide, 5 mm. thick.

Types: Holotype, U. S. Nat. Mus. 91786. Paratypes, U. S. Nat. Mus. 91786*a;* Nat. Mus. Canada 8867.

Locality.—East and south sides of Perron Boulevard just before the descent into The Amphitheater.

EXPLANATION OF PLATE 52

U.S.N.M., U. S. National Museum; N.M.C., National Museum of Canada.

FIGS. *1, 4, 7—Cyclospira glansfagea* Cooper and Kindle, n. sp., ×2, Priest's Road. *1, 7,* Ventral and dorsal views of holotype, U.S.N.M. 91800. *4,* Side view of a paratype, U.S.N.M. 91800*a*. (p. 359)

2, 3, 5, 6—Rhynchotrema plicata Cooper and Kindle, n. sp., ×1, Priest's Road. *2,* Ventral valve, holotype, U.S.N.M. 91785. *3,* Dorsal valve, paratype, U.S.N.M. 91785*a*. *5, 6,* Ventral valves, paratypes, N.M.C. 8865*a*. (p. 359)

8–13, 18—Catazyga cartieri Cooper and Kindle, n. sp., ×1, The Amphitheater. *9–12, 18,* Anterior, ventral, lateral, dorsal, and posterior views of holotype, U.S.N.M. 91786. *8, 13,* Dorsal and ventral views of a paratype, N.M.C. 8867. (p. 359)

14—Cyclopyge sp., ×3, showing strong segmentation; U.S.N.M. 91804; Grand Coupé. (p. 367)

15, 17, 22, 23, 35—Sphaeragnostus gaspensis Cooper and Kindle, n. sp., syntypes. *15,* Cephalon, ×2, U.S.N.M. 91802; *23,* cephalon, ×2, N.M.C. 8868; Priest's Road. *17,* Pygidium, ×3, U.S.N.M. 91810; *22,* pygidium, ×3, N.M.C. 8868*a*; Grande Coupé. *35,* Pygidium, ×3, N.M.C. 8868*b;* Priest's Road. (p. 361)

16, 24—Proetus subornatus Cooper and Kindle, n. sp., ×3, Priest's Road. *16,* Pygidium thought to belong to the species, paratype, U.S.N.M. 91797*a*. *24,* Dorsal view of an imperfect cephalon, holotype, U.S.N.M. 91797. (p. 364)

19, 25, 28—Tretaspis elevata Cooper and Kindle, n. sp., top, front, and side views, ×1, of a large head; holotype, U.S.N.M. 87439; Priest's Road. (p. 361)

20, 31—Remopleurides sp., front and top views, ×2, of a large imperfect head, N.M.C. 8871; Grande Coupé. (p. 363)

21, 26—Ampyx inflata Cooper and Kindle, n. sp., Portage River. *21,* Dorsal view, ×3, of a small head; paratype, U.S.N.M. 91812. *26,* Large specimen, ×2, with free cheeks affixed and two thoracic segments; holotype, N.M.C. 8870. (p. 362)

27, 29, 37—Brachyaspis schucherti Cooper and Kindle, n. sp., side, front, and dorsal views, ×1, of a nearly complete specimen, the holotype, Peabody Mus. (Yale Univ.) 14797; near Corner of the Beach. (p. 363)

30, 38—Otarion sp., side and dorsal views, ×3, of an imperfect head, U.S.N.M. 91803; Grande Coupé. (p. 364)

32, 33, 40—Remopleurides striatus Cooper and Kindle, n. sp., ×3, Priest's Road. *32, 33,* Imperfect pygidia, paratypes, U.S.N.M. 91796*a,b*. *40,* An imperfect cephalon, holotype, U.S.N.M. 91796. (p. 362)

34—Gerasaphes similaris Cooper and Kindle, n. sp., imperfect but well-preserved head, ×3; holotype, U.S.N.M. 91791; Priest's Road. (p. 364)

36, 39, 41–51—Phylacops vigilans Cooper and Kindle, n. gen. and sp. *36,* Imperfect pygidium, ×3, paratype, N.M.C. 8872*b;* Grande Coupé. *39,* Ventral view, ×2, of the eye; *45,* side view, ×3; paratype, N.M.C. 8872*a*; Grande Coupé. *41, 43, 48,* Front, side, and dorsal views, ×3, of a large cephalon showing the glabellar furrows; paratype, U.S.N.M. 91818; Portage River. *42, 44, 47, 49, 50,* Dorsal, head, tail, front, and side views, ×5, of holotype, U.S.N.M. 91819; Grande Coupé. *46, 51,* A nearly complete individual, ×1 and ×5, paratype, N.M.C. 8872, Portage River. (p. 367)

Cooper and Kindle, Ordovician Brachiopods and Trilobites

UNIV. OF MICH.

Discussion.—Of the known species of *Catazyga*, *C. cartieri* is closest to *C. headi* and *C. schuchertana*. It differs in having uniformly stronger costellae, more convex valves and a sharper, more carinate beak and umbo on the ventral valve. As with species of *Catazyga* occurring in southwestern Ohio, *C. cartieri* is represented by narrow and by broad forms, but there seem to be no grounds to separate the specimens as species or varieties.

TRILOBITA

SPHAERAGNOSTUS Howell and Resser Ms., n. gen.

Cephalon convex, smooth, without furrows. Pygidium somewhat smaller than cephalon, with a narrow rim, and with a furrow separating a subcircular rhachis which occupies over half the area of the shield.

Genotype: *Agnostus similaris* Barrande, Système Sil. du Centre de la Bohême, Suppl., pp. 144, 145, pl. 14, fig. 17, 1872.

Range: The genotype occurs in the D1 division of the Bohemian Ordovician, which is approximately Chazyan in age and a new species occurs in the Whitehead limestone.

Discussion.—*Sphaeragnostus* most resembles the genera which have a cephalon devoid of furrows, such as *Phalacroma* Corda, from the Middle Cambrian, and *Leiagnostus* Jaeckel, from the *Echinosphaerites* zone. It is at once distinguished from these genera by the pygidial furrow that delimits the subcircular rhachis.

SPHAERAGNOSTUS GASPENSIS Cooper and Kindle, n. sp.

Plate 52, figures 15, 17, 22, 23, 35; text-figures 10, 11

Cephalon: In outline oval, a little narrowed in front, truncated behind; in profile greatest convexity behind middle, slope to front margin gentle; surface perfectly smooth except for a small tubercle situated halfway between posterior and anterior margins.

Thorax: Unknown.

Pygidium: Elliptical in outline, with anterior end of ellipse truncated; anterior half elevated strongly, forming the highest part, with a tubercle located at highest point, about one-fifth the length of the tail from its anterior margin. Front half of tail subcircular in outline, overlying a lingulate field posterior to it. This field gently convex, surrounding back and sides of the strongly elevated rhachis, from which it is separated by a shallow sulcus. Rim narrow, widest at posterior, surrounding sides and posterior of tail. Surface minutely punctate.

Measurements: Syntypes, cephala, 6 mm. long, 5 mm. wide, 1.5 mm. high; 3 mm. long, 2.5 mm. wide, 0.9 mm. high; pygidia, 5.5 mm. long, 4.5 mm. wide, 1.5 mm. high; 4 mm. long, 3.5 mm. wide, 0.8? mm. high; 4.5 mm. long, 4? mm. wide, 1.2 mm. high.

Syntypes: U. S. Nat. Mus. 91802, 91810; Nat. Mus. Canada 8868.

Localities.—Grande Coupé, Priest's Road.

Discussion.—*S. gaspensis* differs from *S. similaris* in being more elongate and in having less blunt extremities.

TRETASPIS ELEVATA Cooper and Kindle, n. sp.

Plate 52, figures 19, 25, 28

This species is represented in the collections by three cranidia, none complete; one, the holotype, is fairly well preserved. Outline of head semi-elliptical, most convex in front; width nearly three times the length. Glabella flask-shaped, with highly elevated pseudo-frontal lobe and narrow but rather elevated glabellar stalk; glabellar furrows indistinct; occipital ring narrow, depressed; pseudo-glabellar lobe high, narrow when viewed from front, with sides gradually tapering dorsally, narrowly rounded at top. Genal areas in form of a triangle elongated laterally; near pseudo-frontal glabellar lobe these areas are faintly convex but slope with gentle concavity to genal angles. Pleuro-occipital furrow shallow,

narrow near occipital extremity, widening and deepening laterally, terminating at dorsal margin of frontal border. Owing to the fact that most of the specimen is preserved in the form of an internal impression the ocelli were not observed. Frontal border exceedingly narrow; instead of being directed ventrally it extends antero-ventrally so as to make a very small angle with genal areas. Immediately in front of pseudo-frontal lobe a single row of large elliptical pits; laterally and on sides of head a double row of smaller, rounder pits. So far as can be observed the surface, other than the frill, is smooth.

Thorax, pygidium unknown.

Measurements: Holotype, 11 mm. long, 28? mm. wide, height of head, 6 mm.

Types: Holotype, U. S. Nat. Mus. 87439. Paratypes, Nat. Mus. Canada 8869.

Localities.—Rare in crystalline limestone along the Priest's Road; shaly limestone in a pasture one mile from the coast and about a quarter of a mile east of Brêche à Manon, near the western border of Percé township.

Discussion.—This species differs very strongly from the abundant *T. clarkei* of the Grande Coupé and Priest's Road. *T. elevata* can be readily recognized by its narrow frontal border, depressed to concave genal areas, and the strongly elevated and narrow pseudo-frontal lobe of the glabella.

AMPYX INFLATA Cooper and Kindle, n. sp.

Plate 52, figures 21, 26

Cephalon: A greatly inflated, narrowly elliptical glabella rising almost as high above cheeks as glabella is wide; between a third and a half of inflated portion extending forward beyond anterior margin of cephalon; at front of this a spine, round in cross-section, total length of which is unknown as each specimen is broken at the end. Posterior to inflated portion of glabella a pair of short glabellar furrows. Genal spine long, starting at genal angle almost at right angles to axis of the trilobite and curving gently backward. Genal spines not complete in our specimen. Free cheek about same in width as genal spine, appearing to extend about half way from genal angle to median line of cephalon. Post-marginal furrow not discernible near glabella but more definite nearer genal angle, where it ends in a small pit.

Thorax: Two thoracic segments are preserved attached to the larger specimen. Axial portion about one-fifth the width of the segment; a furrow on pleural portions and a small protuberance on each side of axial portion of segments.

Pygidium: None found.

Measurements: Smaller specimen, 2.4 mm. long, 4 mm. wide, incomplete spine 1.6 mm. long. Larger specimen, 5 mm. long, 8 mm. wide, incomplete spine, 1 mm. long.

Types: Holotype, Nat. Mus. Canada 8870. Paratype, U. S. Nat. Mus. 91812.

Locality.—Portage River.

Discussion.—The glabella of *A. inflata* is more convex and more inflated than that of any species referred to *Ampyx* or *Raphiophorus* by Angelin.

REMOPLEURIDES STRIATUS Cooper and Kindle, n. sp.

Plate 52, figures 32, 33, 40

Cephalon: Glabella almost as long as wide, covered with fine undulating striations that curve backward on either side from the median region. Three pairs of glabellar furrows indicated by interruptions in the striations but not easily seen; first very short, situated about midway from median axis to axial furrow; second long, at right angles to median axis; third wider than the others, curving on the inside slightly towards the rear. Tongue of glabella very wide, almost three-quarters the greatest width of glabella. Glabella as a whole moderately convex except at front where tongue bends down at right angles to the rest of the glabella. Broad occipital ring with striations continuous with those of gla-

bella, but much finer; on anterior margin of occipital ring a small median tubercle. Occipital furrow deep, narrow; axial furrow deep; palpebral lobes narrow, without striations. Eyes unknown.

Pygidium: Smooth, ending in four spines, middle pair longer than outer pair. Axis about half length of pygidium, two-thirds its width; composed of two segments; first narrow in middle, widening at extremities; second divided into a pair of oval lobes which diverge posteriorly, a median ridge separating them, continuing down to notch between long pair of spines. A very shallow depression runs from end of first axial segment to base of first spine; not visible on exfoliated specimens. On anterior margin on either side of first axial segment a projecting knob which apparently articulates with a corresponding socket in last thoracic segment.

Measurements: Cephalon, 4.5 mm. long; glabella, 3.5 mm. long, 4 mm. wide. Pygidium, 4 mm. long, 4 mm. wide.

Types: Holotype, U. S. Nat. Mus. 91796; paratypes, U. S. Nat. Mus. 91796 *a,b*.

Locality.—Crystalline limestone along the Priest's Road.

Discussion.—The cephalon of *R. striatus* is close to that of *R. latifrons* Holm, from Sweden, as described by Miss Warburg, but has a median tubercle on the occipital ring. Viewed from the front, the anterior margin of the glabella is more strongly arched upward, so that it parallels the top of the glabella as seen from that direction. No pygidium is known of *R. latifrons*, and the closest pygidia to compare with this are *R. quadrispinus* (Angelin) from Norway and *R. portlocki* Reed from Scotland. From both of these our specimens differ in having a smooth surface, from the latter in the shallow depression extending from the first axial segment to the base of the first spine and seeming continuous with it instead of coming partly inside it, as Reed's figure shows.

REMOPLEURIDES sp. ind.
Plate 52, figures 20, 31

A fragmentary cephalon from the Grande Coupé and other fragments from the Priest's Road differ greatly from *R. striatus* in being twice as large, in having a smooth cephalon, except near the axial furrow where it is finely tuberculate, and in having a narrower glabellar tongue which bends down much farther than in the small species. The two species are similar in having a median tubercle situated on the anterior margin of the occipital ring.

Figured specimen: Nat. Mus. Canada 8871.

BRACHYASPIS SCHUCHERTI Cooper and Kindle, n. sp.
Plate 52, figures 27, 29, 37

A complete specimen was found in place by Professor Schuchert, south of Corner of the Beach and west of the English Church, beside the road and brook. Specimen about 26 mm. long, lacking rear margin of pygidium and posterior axial portion of cephalon. Agrees with *B. alacer* (Billings) from Anticosti and *B. sussae* (Whitfield) from the upper Mississippi valley in having the eyes nearly on a level with the central portion of the cephalon, which is only slightly convex from eye to eye. Axial portion of thorax in width about equal to one-third total width of thorax. Differs from *B. alacer* in having a less convex cephalon and pygidium and sharp genal angles. In fact, it appears to have had short genal spines that have been broken off. A cast of the type specimen of *B. alacer*, which we had for comparison, seems to have rounded genal angles.

Holotype: Yale Peabody Mus. 14797.

Discussion.—The chief differences between *B. alacer* and *B. schucherti* are the gentler slope of the head to the front margin in the latter, the flatter head between the eyes, more depressed eyes, more tapering axis, less convex tail, and conspicuous flattening of the pleural portion of the thoracic segments.

GERASAPHES SIMILARIS Cooper and Kindle, n. sp.

Plate 52, figure 34

Cranidium small, gently convex, with elevated palpebral lobes bordering the eyes; greatest width in front of eyes. Glabella not clearly marked off by furrows from rest of cephalon. Pre-glabellar area very narrow, gently concave. Occipital ring elevated at rear margin; in front of it a wide, shallow occipital furrow. At base of glabella an elevated median node; glabella extending horizontally anterior to this node about half the length of the glabella before curving down toward pre-glabellar furrow; central posterior part of glabella an elevated ridge about one-third width of glabella in that region; a pair of deep lateral glabellar furrows marking off this central ridge on either side about in a line, or slightly anterior to a line, drawn through middle of palpebral lobes; furrows crescentic, concave posteriorly. About in line with front of palpebral lobes another pair of furrows similar in shape but quite faint, the first pair of lateral glabellar furrows. Between this first pair of furrows and third pair (the deep ones) a very faint second pair visible under a good light; straight. A short narrow ridge extending from what might be the postero-lateral corner of glabella toward basal median node of glabella, bounded both anteriorly and posteriorly by narrow furrows.

Measurements: Holotype, 5 mm. long, 4 mm. wide.

Holotype: U. S. Nat. Mus. 91791.

Locality.—Priest's Road.

Discussion.—*G. similaris* greatly resembles *G. ulrichana* Clarke, but has a narrower pre-glabellar area. Clarke proposed the subgenus *Gerasaphes* for a small *Asaphus* with a strongly ribbed pygidium.

ISOTELUS sp.

Plate 53, figure 40

A large exfoliated tail, 77 mm. wide, 46 mm. long, is referred to *Isotelus*. The specimen comes from the thin-bedded, limestones exposed south of Mont Joli in Percé village.

Figured specimen: U. S. Nat. Mus. 91824.

OTARION sp.

Plate 52, figures 30, 38

A cephalon from the Grande Coupé resembles *O. minima* Cooper in its proportions, but differs in being larger and covered with rather coarse tubercles and in lacking the median neck tubercle. Glabella tumid, strongly convex in profile. Occipital nodes small. Preglabellar field convex, wide, angular at each lateral extremity. Anterior border broken away.

Figured specimen: U. S. Nat. Mus. 91803.

PROETUS SUBORNATUS Cooper and Kindle, n. sp.

Plate 52, figures 16, 24

Cranidium: Glabella moderately convex, two-thirds the length of the cranidium, tapering only slightly toward front, where it is rounded off bluntly; facial sutures diverging slightly anteriorly; almost flat occipital ring and preglabellar field, turned-up anterior border; preglabellar field about same width on axis as the occipital ring; a median tubercle on occipital ring which is closer to posterior margin than anterior; surface marked by raised striations interrupted by glabellar furrows; glabellar furrows faintly marked, inclined at an angle of about 50° to axis, first pair short, second pair intermediate in length between first and third pairs, second and third pairs somewhat triangular in shape. The length of the cranidium is 6 mm.

Pygidium: A pygidium thought to belong to this species has the following characters: about twice as wide as long; axis strongly elevated, with a length of 2 mm. and a width of 4 mm.; about 1.5 mm. wide at anterior end, tapering gradually but terminated abruptly, contain-

ing three distinct segments but the posterior half nearly smooth; pleural lobes depressed convex, moderately strongly segmented throughout.

Measurements: Cranidium, 6 mm. long. Pygidium, 2 mm. long, 4 mm. wide.

Types: Holotype, cranidium, U. S. Nat. Mus. 91797. Paratype, pygidium, U. S. Nat. Mus. 91797*a*.

Locality.—Priest's Road.

Discussion.—*P. subornatus* resembles *P. decorus* Barrande in its ornamentation and general shape, but the glabella is not as convex, nor the preglabellar field as short; it differs from *P. modestus* Törnquist in having a shorter glabella and less widely diverging facial sutures anteriorly.

PROETUS cf. P. CONVEXUS Warburg

Plate 53, figure 19

An imperfect cranidium from the Priest's Road strongly resembles *P. convexus* Warburg: length 6 mm.

Figured specimen: U. S. Nat. Mus. 92466.

PHAETHONIDES BELLUS Cooper and Kindle, n. sp.

Plate 53, figure 15

One cranidium 4.5 mm. long. Glabella strongly convex, separated from the upturned anterior border by a deep preglabellar furrow, from the broad, convex occipital ring by an equally deep occipital furrow. Presence or absence of an occipital tubercle indeterminate, as top of ring is missing. Pair of occipital lobes present as oval swellings on anterior lateral borders of occipital ring. A pair of deep, straight, glabellar furrows marking off large oval basal lobes; these furrows inclined at a very small angle to axis but as they do not reach the occipital furrow they do not completely cut off the lobes from the rest of the glabella; three other pairs of glabellar furrows present anterior to these; first short, shallow, difficult to see, situated near side of glabella, extending at right angles to axis; second pair long, extending from lateral furrow in at an angle of about 80° to axis, with distance of half the width of the glabella between inner ends of furrows; third pair short, deep, parallel to second pair. On occipital ring a pair of short deep depressions that extends posteriorly from occipital furrow on each side, medianly under basal glabellar lobes and inside occipital lobes. Surface covered by fine raised lines.

Holotype: U. S. Nat. Mus. 91790.

Locality.—Priest's Road.

Discussion.—*P. bellus* differs from *P. stokesi* (Murchison) in having three anterior pairs of glabellar furrows. Likewise Miss Warburg's "*Phaethonides* sp. ind." shows faint glabellar furrows, the third pair longer than the second. From both *P. bellus* differs in lacking a preglabellar field, the glabella reaching the anterior border.

Family CYCLOPYGIDAE Raymond, 1925

In their study of the "Silurian" Fossils of the Girvan District, in Ayrshire, Scotland, Nicholson and Etheridge in 1880 found that the genus *Cyclopyge* (known to them as *Aeglina*) could be subdivided into three well-marked groups that might in the future be designated by distinct names. Their divisions were:

A. *Cyclopyge* proper. Forms having the anterior margin of the glabella intact, i.e., not produced into a frontal spine; eyes lateral in position, not united in front. An example is *C. rediviva* Barrande.

B. Forms with a similar anterior margin of the glabella; eyes much enlarged, extending forward, united in front of the head to form one large optical organ. An example is *C. mirabilis* Forbes (Salter, 1853). This is the new genus *Phylacops* Cooper and Kindle.

C. Forms with the anterior part of the glabella produced into a frontal spine, and the eyes as in division *B*. An example is *C. armata* Barrande. This is the genus *Symphysops* Raymond.

Cyclopyge may have none, or one, two, or three pairs of glabellar furrows; *Phylacops* has one; and *Symphysops* has two pairs of glabellar furrows.

It is interesting to find in one formation in North America the three genera of this family, known in Europe only at scattered localities. The only other indications of the presence of the family in North America are Ami's reports of *C. rediviva* from Quebec City and *C.* sp. from the Phillipsburg series near Farnham, Quebec; both reports are doubtful.

PHYLACOPS Cooper and Kindle, n. gen.

Etymology: φύλαξ, sentinel; ὄψ, eye.

One of the Cyclopygidae with eyes meeting in front as in *Symphysops* Raymond, but with the frontal portion of the glabella not produced into a spine; one pair of glabellar furrows.

Beside the genotype this genus includes *P. mirabilis* (Forbes), from the limestone of Portrane, County Dublin, Ireland.

Genotype: *P. vigilans* Cooper and Kindle.

EXPLANATION OF PLATE 53

U.S.N.M., U. S. National Museum; N.M.C., National Museum of Canada.

FIGS. *1, 2, 6, 29, 37–39*—*Sphaerexochus bridgei* Cooper and Kindle, n. sp., syntypes. *1, 2, 6,* Side, dorsal, and front views, ×2, of a small cephalon, U.S.N.M. 91822; Grande Coupé. *29, 37, 38,* Front, dorsal, and side views, ×2, of a large cephalon, U.S.N.M. 91788; *39,* pygidium, ×1½, U.S.N.M. 91788*a;* Priest's Road. (p. 371)

3, 7–10, 12–14, 18, 24—*Symphysops spinifera* Cooper and Kindle, n. sp., Grande Coupé. *3, 9, 10, 24,* Side, ventral, anterior, and dorsal views, ×2, of a cephalon showing the groove under the snout and the swelling posterior to the snout, paratype, N.M.C. 8873. *7, 13,* Ventral and side views, ×2, of an eye, paratype, U.S.N.M. 87436*a*. *8, 14,* Cephalon, ×1 and ×2, showing complete spine and glabellar furrows, holotype, U.S.N.M. 87436. *12,* Dorsal view, ×3, of pygidium, paratype, N.M.C. 8873*a*. *18,* Pygidium, ×2, paratype, U.S.N.M. 87436*b*. (p. 367)

4, 11, 36—*Sphaerocoryphe* sp., ×2. *4, 11,* Imperfect cephalon preserving part of a fixed cheek, N.M.C. 8877; Grande Coupé. *36,* Front view of fragmentary cephalon, U.S.N.M. 91801; Priest's Road. (p. 371)

5—*Pharostoma rarum* Cooper and Kindle, n. sp., dorsal view, ×3, of a small imperfect cephalon, holotype, U.S.N.M. 91795; Priest's Road. (p. 369)

15—*Phaethonides bellus* Cooper and Kindle, n. sp., imperfect cephalon, ×3, holotype, U.S.N.M. 91790; Priest's Road. (p. 365)

16, 22—*Platylichas parvus* Cooper and Kindle, n. sp., dorsal and side views, ×2, of a small, imperfect head, holotype, U.S.N.M. 87448; Priest's Road. (p. 368)

17—*Symphysops* sp., side view, ×2, of a large eye, U.S.N.M. 91809; Grande Coupé. (p. 368)

19—*Proetus* cf. *P. convexus* Warburg, imperfect cephalon, ×2, U.S.N.M. 92466; Priest's Road. (p. 365)

20—*Ceraurus binodosus* Cooper and Kindle, n. sp., imperfect cephalon showing the large nodes on the glabella, ×1, holotype, U.S.N.M. 91799; Priest's Road. (p. 369)

21, 28—*Ceraurus* sp. 2, two imperfect exfoliated cephala, ×2, Irishtown Road; *21,* N.M.C. 8875; *28,* U.S.N.M. 91813. (p. 370)

23, 33—*Amphilichas rubrus* Cooper and Kindle, n. sp., side and dorsal views, ×1, of an imperfect cephalon, holotype, U.S.N.M. 91811; near Whitehead Lighthouse. (p. 368)

25, 27—*Ceraurus* sp. 1, two imperfect cephala, ×2, Priest's Road; *25,* U.S.N.M. 91789; *27,* N.M.C. 8874. (p. 370)

26, 34—*Cyclopyge angustata* Cooper and Kindle, n. sp., dorsal and front views, ×2, of holotype, U.S.N.M. 91908; Grande Coupé. (p. 367)

30, 35—*Achatella* sp., two imperfect cephala, ×2, Priest's Road; *30,* N.M.C. 8878; *35,* U.S.N.M. 91794. (p. 371)

31, 32—*Cheirurus percensis* Cooper and Kindle, n. sp., ×1. *31,* Large pygidium, holotype, U.S.N.M. 91792; Priest's Road. *32,* Fragment of cephalon thought to belong to this species, paratype, U.S.N.M. 91814; Malbaie-Rameau Township line. (p. 370)

40—*Isotelus* sp., impression of lower side of large pygidium, ×1½, U.S.N.M. 91824, South Cove. (p. 364)

Cooper and Kindle, Ordovician Trilobites

UNIV. OF MICH.

PHYLACOPS VIGILANS Cooper and Kindle, n. sp.

Plate 52, figures 36, 39, 41–51

Cephalon: Nearly as broad as long; one pair of glabellar furrows situated one-third the length of the head from posterior margin, inclined at an angle of 70° to axis of head; posterior to each furrow a circular swelling, the diameter of which approximates the length of the glabellar furrow. On median axis a similar distance anterior to glabellar furrows a small tubercle. Surface smooth. Eyes extend along length of head, meet in front. Fixed cheeks narrow, separated from sides of head by a narrow groove which runs around the sides and front of head; this groove flexed anteriorly and separating from the head an angular ridge to which eyes are attached.

Thorax: The two complete specimens both immature; number of segments in the adult uncertain; the smaller, enrolled specimen has four thoracic segments; the extended one five. Axial lobe rather strongly elevated, its width decreasing rapidly from anterior segments to posterior ones; in first thoracic segment axial lobe more than half the width of the segment; in posterior segment, only about one-third.

Pygidium: Pygidium wider than long, gently rounded at its posterior margin. Axial lobe extending about a third the length of pygidium; one segment definitely defined on both axis and pleural regions; a second segment less clearly marked. A definite band deflected downwards at posterior extremity runs around posterior margin of pygidium.

Measurements: Cephalon, adult, 6 mm. long; an extended complete individual, 3 mm. long; holotype, 2.5 mm. long.

Types: Holotype, U. S. Nat. Mus. 91819. Paratypes, U. S. Nat. Mus. 91818; Nat. Mus. Canada 8872,*a*,*b*.

Localities.—Most of the specimens are from the talus slopes of the Grande Coupé; complete extended individual and several pygidia from Portage River; one pygidium from the Priest's Road.

Discussion.—The only known form like *P. vigilans* is *P. mirabilis* (Forbes), which has a much narrower glabella and more convex eyes. The glabellar furrows are inclined at a much smaller angle to the axis of the glabella than in *P. vigilans*.

CYCLOPYGE ANGUSTATA Cooper and Kindle, n. sp.

Plate 53, figures 26, 34

A single cephalon, narrower, particularly in anterior part, than *C. kindlei* Cooper; a small, elongate median tubercle about halfway between anterior and posterior margins, contrasting in position with the faint anterior tubercle of *C. kindlei*.

Measurements: 5.5 mm. long, 5 mm. wide at maximum, 1 mm. wide at front margin.

Holotype: U. S. Nat. Mus. 91908.

Locality.—Grande Coupé.

CYCLOPYGE sp.

Plate 52, figure 14

A small pygidium differs from other species from this region in being segmented; from *Phylacops vigilans* in being more strongly segmented and in having two segments on the pleural lobes. The pygidium may belong to *C. angustata*.

Figured specimen: U. S. Nat. Mus. 91804.

Locality.—Grand Coupé.

SYMPHYSOPS SPINIFERA Cooper and Kindle, n. sp.

Plate 53, figures 3, 7–10, 12–14, 18, 24

Cephalon: Sub-pentagonal in outline, apex of pentagon drawn into a short, sharp spine with nearly circular cross-section; in profile highest at a point one-quarter the length from the base of the spine, where there is a swelling, flat or very gently convex from this point to posterior margin; just anterior to highest point a small, elongated median tubercle. In posterior half two strong, rather deep glabellar furrows at about right angles

to axis of head; posterior margin gently curved; a narrow furrow separating the greatly elongated, narrow palpebral lobe from glabella. Fixed cheek reduced to small triangular process located at angle between sides and posterior margin of head. Beneath spine on anterior side of head a narrow furrow separating a narrow, raised border from a small bulbous swelling.

Eye: One complete eye is thought to belong to this species. About three times as long as wide, narrowed in front where ventral portion of head is inserted; ventral surface strengthened by a wide doublure marked by numerous wavy lines; on each side of doublure along its posterior margin near the point where the doublure narrows, two small, blunt processes.

Thorax: unknown.

Tail: About twice as wide as long, with strong, bluntly pointed axis showing three segments only; pleural lobes obscurely segmented; lateral and posterior border rather broad, convex.

Measurements: Holotype head, 15 mm. long, 10 mm. wide; spine, 2 mm. long. Eye, 9 mm. long, 3.5 mm. wide. Pygidium, 5 mm. long, 10 mm. wide.

Types: Holotype: U. S. Nat. Mus. 87436. Paratypes, U. S. Nat. Mus. 87436*a,b;* Nat. Mus. Canada 8873,*a*.

Localities.—Grande Coupé, Priest's Road, Portage River.

Discussion.—*S. spinifera* is close to *S. armata* (Barrande) and to *S. subarmata* (Reed), but in *S. armata* the first pair of glabellar furrows is about midway between the anterior and posterior borders of the glabella, and in *S. subarmata* the median tubercle lies near the base of the glabella. Lack of knowledge of the thoracic region permits no comparison with the long spines on the first thoracic segment of *S. subarmata*.

Symphysops sp.

Plate 53, figure 17

At the Grande Coupé there is a second species of *Symphysops* represented in the collections by a fragment of a large eye. This eye, as indicated by the left side, is shorter and wider, and has larger facets than the eye of *S. spinifera*.

Figured specimen: U. S. Nat. Mus. 91809.

Amphilichas rubrus Cooper and Kindle, n. sp.

Plate 53, figures 23, 33

An incomplete cranidium resembles *A. latifrons* Warburg in general proportions but differs in having the three lobes of the glabella more convex transversely, the central lobe less convex longitudinally, and the ornamentation of coarser tubercles.

Cephalon roughly triangular; one pair of glabellar furrows running forward from occipital furrow almost parallel for half the length of the glabella, then diverging to meet the axial furrow so that lateral anterior angle of central lobe is about 45°. A portion of a broad neck ring is preserved that extends laterally beyond the axial furrow about a third the width of the fixed cheek.

Measurements: Glabella, 14 mm. long, 17 mm. wide, 14 mm. wide at base. Central lobe, 4.5 mm. wide at base, 14 mm. wide at front, 5 mm. wide at eye-line. Tri-composite lobe, 5.5 mm. wide at eye-line, 10 mm. long.

Holotype: U. S. Nat. Mus. 91811.

Locality.—Sea cliffs at first stream north of Whitehead lighthouse.

Platylichas parvus Cooper and Kindle, n. sp.

Plate 53, figures 16, 22

Cranidium very convex in front; anterior margin narrow, near middle of glabella bent down in same direction as glabella but laterally becoming more distinct, horizontal; the three lobes of glabella gently convex, rising to same elevation; base of central lobe marked by three shallow depressions, one transverse in line with furrows posterior to the bi-composite lobes, and a pair marking off indistinct nodules on lateral pos-

terior corners of central lobe; lateral and axial glabellar furrows strongly marked except axial furrow posterior to bi-composite lobe between it and occipital furrow, where furrow is less strongly impressed. A narrow elongate lobe marked off on fixed cheek in front of occipital furrow, extending distally from junction of axial and occipital furrows; this basal lobe is in line with deeply impressed middle portion of occipital furrow. Surface of entire specimen covered with small tubercles.

Measurements: Glabella, 5 mm. long, 6 mm. wide.

Holotype: U. S. Nat. Mus. 87448.

Locality.—Priest's Road.

Discussion.—This species differs from *P. latus* Törnquist in having a transverse depression across the basal part of the central glabellar lobe, the inner posterior parts of the bi-composite lobes form a blunt angle instead of a rounded termination, the cranidium wider and the bi-composite lobes proportionately wider.

ENCRINURUS sp.

A pygidium from the Grande Coupé agrees in most characters with *E. percëensis* Cooper but differs in having a finely tuberculate surface. These tubercles are noticeable particularly along the sides of the elevated portions of the pleurae.

Unfigured specimen: U. S. Nat. Mus. 91805.

PHAROSTOMA RARUM Cooper and Kindle, n. sp.

Plate 53, figure 5

Surface of the single specimen known closely covered with various sizes of tubercles. Glabella strongly convex; furrows mark off on it two distinct lateral lobes, of which posterior is larger; furrows shallow at posterior inner side of these lobes, so that they appear to be connected there with the rest of the glabella. Preglabellar area nearly flat, about same width as anterior border, which is turned upwards. A deep occipital furrow marks off occipital ring; on top median portion a large tubercle, not larger than others on surface of cephalon. Palpebral lobes elevated, placed slightly anterior to a line drawn through first pair of lateral glabellar lobes and about width of these lobes from glabella.

Measurements: Cephalon, 3 mm. long, a little more than 4 mm. wide.

Holotype: U. S. Nat. Mus. 91795.

Locality.—Priest's Road.

Discussion.—*P. rarum* is very similar to *P. leptaenarum* Törnquist, as figured by Miss Warburg from the Leptaena limestone of Sweden. In that species, however, the anterior border is not turned up but is flat and has a fringe of forward directed spines. *P. rarum* has a rough border, owing to the tuberculate surface, but no spines are present.

CERAURUS BINODOSUS Cooper and Kindle, n. sp.

Plate 53, figure 20

Glabella defined anteriorly by a narrow, flat border, laterally by a convex fixed cheek. Between anterior border and fixed cheek a deep furrow at right angles to axis, joining axial furrow only slightly anterior to first glabellar furrow. Fixed cheek ornamented with pits and tubercles, anterior border with fine tubercles, rest of cranidium with larger scattered tubercles. Glabella quite convex, widening a little anteriorly; widest at the posterior part of frontal lobe; about on this line of greatest width two highly swollen protuberances, not bases of spines for their surface is ornamented with smaller tubercles as are other parts of glabella; large tubercles on rear of glabella and near front margin an unsymmetrical row of four large tubercles which are ornamented with finer tubercles. Three pairs of glabellar lobes, all straight, the first inclined about 45°, the others at 90° to axial furrow; lobes about equal in size, the first two not separated by a longitudinal depression from rest of glabella as with the basal lobe; a slight depression crosses glabella

in line with third pair of glabellar furrows. Occipital furrow deep medianly, curving forward to meet basal lobes at about middle of their inner sides, curving abruptly thence around basal lobe. Occipital ring broad, elevated toward rear margin, at highest point of which is a large tubercle.

Holotype: U. S. Nat. Mus. 91799.

Locality.—Priest's Road.

Discussion.—*C. binodosus* differs greatly from *C. bispinosus* Raymond and Barton, Black River limestone near Hull, Quebec, in the position and size of the glabellar lobes and in the position of the protuberances. Of the two specimens of *C. bituberculatus* Troedsson, Cape Calhoun (Richmond) beds of Greenland, known and figured by Troedsson, the Percé species more closely resembles specimen 336 (Pl. 17, fig. 11) in the relation of the neck furrow and the basal lobe but differs in having no furrows on the inner sides of the first two pairs of glabellar lobes, and in having the frontal lobe the widest part of the glabella.

Ceraurus sp. 1

Plate 53, figures 25, 27

Nine incomplete cranidia of *Ceraurus* in general characters resemble *C. pleurexanthemus* Green but differ in having genal spines that curve backward almost parallel to the axis and do not flare apart widely. The surface of the genal spines and of the borders are, moreover, ornamented with tubercles in the same manner as the rest of the cephalon, whereas in *C. pleurexanthemus* these parts have only a fine ornamentation.

Measurements: Cephala, 9 mm. long, 26 mm. wide; 7 mm. long, 19 mm. wide; 6 mm. long, 18 mm. wide.

Figured specimens: U. S. Nat. Mus. 91789; Nat. Mus. Canada 8874.

Locality.—Priest's Road.

Ceraurus sp. 2

Plate 53, figures 21, 28

Five incomplete exfoliated cranidia show an ornamentation of a few small scattered tubercles. Rear of glabella and neck ring very convex. Fixed cheeks also quite convex, so that axial furrow is very deep, particularly where a branch diverges at right angles opposite the first lateral glabellar furrow; in front of this branch furrow surface rises, anterior margin at a much higher level than axial furrow. Anterior border narrow, almost merging with glabella near middle. Palpebral lobes farther from glabella than the posterior margin. These exfoliated heads may belong to the species described above, but the point cannot be settled with the present material.

Figured specimens: U. S. Nat. Mus. 91813; Nat. Mus. Canada 8875.

Locality.—Irishtown Road, quarter of a mile west of the Anglican church.

Cheirurus percensis Cooper and Kindle, n. sp.

Plate 53, figures 31, 32

The head tentatively assigned to this species preserves less than half the cephalon. The axial and glabellar furrows resemble rather closely those of the heads of *C. clasoni* Törnquist, but the glabellar furrows curve more strongly to the rear. Pygidium with four axial lobes, to first three of which are attached pairs of pleurae; pleurae expanding distally to a maximum width, beyond which they are free, ending in spines. Anterior border of first pair of pleurae extending laterally at right angles to axis to point of maximum width, then bending sharply to rear almost parallel with axis; a deep furrow in this pleura extending from axial furrow about half way to line of maximum width. Second pleura without furrow; axial furrow separating second pleura less strongly marked than with first pleura. With third pleura axial furrow so faint as to be barely discernible in the exfoliated specimen. Fourth axial lobe without pleurae but bordered by the third pair of pleurae, which end in a short pair of spines separated by a short, transverse median portion of pygidium. Spines of second pair of pleurae extending to about same level as third pair; those of first pair broken off, making it

impossible to determine whether or not they also come to the same level. Strong articulating ring at anterior border of pygidium, and what appears to be a remnant of one at posterior border of first axial segment. Character of surface ornamentation cannot be determined in our specimen.

Measurements: Pygidium, 11 mm. long, 22 mm. wide; cephalon, 17 mm. long.

Types: Holotype, U. S. Nat. Mus. 91792; paratype, U. S. Nat. Mus. 91814.

Locality.—This species is based on an incomplete pygidium from the crinoidal limestone of the Priest's Road. The fragmentary cephalon assigned to it comes from a branch of Biscuit Creek where it crosses the 5th range line, near the Rameau-Malbaie township line.

Discussion.—The pygidium resembles *C. clasoni* Törnquist, from the Upper *Leptaena* limestone of Sweden, as described by Miss Warburg; and less closely, *C. keisleyensis* Reed, from the Keisley limestone of England. The second pair of pleurae in *C. keisleyensis* is much more narrow and longer than in *C. percensis*. *C. percensis* differs from *C. clasoni* in having a much wider, straight front border on the first pair of pleurae, resulting in a wider pleura; and in lacking the slight posterior prolongation of the median portion of the second axial segment. Miss Warburg's *Cheirurus* sp. B agrees more closely with ours in this respect and in the length of the second pair of pleurae. The axial furrows which separate the third pair of pleurae from the third segment are very faint in our specimen. When allowance is made for the exfoliated surface, a very close resemblance is seen between *C. percensis* and the fragmentary *C.* sp. B of Miss Warburg; when better specimens are found they may prove to be the same.

Sphaerexochus bridgei Cooper and Kindle, n. sp.

Plate 53, figures 1, 2, 6, 29, 37–39

Glabella a little wider than long; surface of cephalon ornamented with fine tubercles except in furrows; all furrows deeply impressed. Our species is similar in general proportions to *S. calvus* McCoy of Miss Warburg, but differs in having a median tubercle on the occipital ring, the axial furrow with a very deep depression at the junction with the first pair of lateral glabellar furrows, the first pair of lateral glabellar furrows turning a little posteriorly on entering the slope into the axial furrow, the palpebral lobe straight on the side next to the eye and only slightly convex on the side toward the fixed cheek. The pygidium has the same broad reëntrant angles as *S. calvus* but differs in the ridge in the second pair of pleurae turning anteriorly at the tip.

Measurements: Cephalon, 10.5 mm. long, 11 mm. wide, 5.5 mm. high. Pygidium, 7.5 mm. long, 15 mm. wide.

Syntypes: U. S. Nat. Mus. 91822, 91788,*a;* Nat. Mus. Canada 8876.

Locality.—A dozen specimens from the Priest's Road.

Sphaerocoryphe sp.

Plate 53, figures 4, 11, 36

A number of specimens of the swollen glabella of *Sphaerocoryphe*, to some of which a portion of the fixed cheek is attached, are not specifically determinable. The surface of the specimens is coarsely papillose.

Figured specimens: U. S. Nat. Mus. 91801; Nat. Mus. Canada 8877.

Localities.—Priest's Road, Grande Coupé.

Achatella sp.

Plate 53, figures 30, 35

A few incomplete cranidia resemble *A. achates* (Billings). These are coarsely tuberculate and have a broad, oval frontal lobe and a longitudinally concave neck-ring. At its lateral extremities the frontal lobe is broadly rounded and thus differs from that of many somewhat similar species of *Pterygometopus*, in which this lobe narrows laterally to a rounded acute angle.

Figured specimens: U. S. Nat. Mus. 91794; Nat. Mus. Canada 8878.

Locality.—Priest's Road.

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CEPHALOPODS FROM THE UPPER ORDOVICIAN OF PERCÉ, QUEBEC

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ABSTRACT

Cephalopods from the Upper Ordovician Whitehead formation of the Percé area, Quebec, now number 23 species in 11 genera. Of these 17 species are described as new. Though some of the genera are long-ranging, the relations of the fauna appear to be closest with that of the Richmond of interior North America; it has little in common with the faunas of nearby Anticosti Island.

In 1930, G. A. Cooper (1) described *Apsidoceras depressum* and *Billingsites logani* from the Whitehead formation at the eastern end of Gaspé peninsula, Quebec. In 1932, A. K. Miller (2) proposed the generic name *Schuchertoceras* for those species formerly assigned to *Billingsites* that have a basal septum a short distance above the septum of truncation and subparallel to the latter, and *Billingsites logani* Cooper then was referred to this new genus *Schuchertoceras*. Since then the number of species of cephalopods known from the Whitehead formation has been increased by Cecil H. Kindle to 19, in addition to which there are 4 species too poorly preserved to merit specific names.

Though the Percé area of Gaspé is scarcely 70 miles from the nearest part of Anticosti Island, not a single species among these cephalopods is known to be common to the two areas. Moreover, none of these Percé cephalopods are identical with any known from the interior of the continent. Under these circumstances no exact correlations are possible.

Tentatively, the cephalopods of the Whitehead formation appear to be of Richmond or earlier age. The species of *Apsidoceras*, *Schuchertoceras*, *Diestoceras*, and *Neumatoceras* here described have no affinities with known post-Richmond species. As to pre-Richmond possibilities, that is a matter of considerable uncertainty. *Schuchertoceras*, *Billingsites*, *Diestoceras*, and *Neumatoceras* are known in Wyoming as low as the Lander sandstone, at the base of the Big Horn formation, and this Lander sandstone appears to correlate with the Stewartville formation in Minnesota and the adjacent parts of Iowa and northwestern Illinois. Only the genus *Apsidoceras* is not known at present beneath the Richmond. On the other hand, no cephalopod is known from the Gaspé area which definitely requires correlation with pre-Richmond strata.

For the present, the fact that not a single cephalopod from the Whitehead formation of Gaspé can be identified with any from Anticosti should be stressed; especially in view of the fact that a similar statement can be made of the cephalopods of the Silurian along the northern shore

of the Bay of Chaleur, which forms the southern margin of the Gaspé peninsula. A considerable cephalopod fauna collected from this Chaleur area by Stuart A. Northrop, G. Arthur Cooper, and others in recent years has been studied by the present writer without finding a single species in common with the Silurian of Anticosti. This difference between the cephalopods of southern Gaspé and those of Anticosti, both in Ordovician and Silurian times, suggests deposition in distinct basins. Little is known of those parts of Gaspé remote from the coast, so that the information bearing on this problem is limited. However, it is significant that, while the Ordovician and Silurian faunas of Anticosti have affinities with the interior of the American continent, they do not show similar affinities with the faunas farther south along the Atlantic coast.

The following species are described in this paper:

1. *Orthoceras gaspense* Foerste, n. sp.
2. *Orthoceras percense* Foerste, n. sp.
3. *Orthoceras kindlei* Foerste, n. sp.
4. *Geisonoceras expansum* Foerste, n. sp.
5. *Donacoceras percense* Foerste, n. sp.
6. *Metaspyroceras kindlei* Foerste, n. sp.
7. *Metaspyroceras gaspense* Foerste, n. sp.
8. *Spyroceras percense* Foerste, n. sp.
9. *Spyroceras liratum* Foerste, n. sp.
10. *Spyroceras? subglabrum* Foerste, n. sp.
11. *Schuchertoceras logani* (Cooper)
12. *Apsidoceras depressum* Cooper.
13. *Apsidoceras* sp.
14. *Beloitoceras* sp.
15. *Neumatoceras latilineatum* Foerste, n. sp.
16. *Neumatoceras striatum* Foerste, n. sp.
17. *Neumatoceras percense* Foerste, n. sp.
18. *Neumatoceras* sp.
19. *Ooceras?* sp.
20. *Diestoceras gaspense* Foerste, n. sp.
21. *Diestoceras cooperi* Foerste, n. sp.
22. *Diestoceras brevidomum* Foerste, n. sp.
23. *Diestoceras subglobosum* Foerste, n. sp.

SYSTEMATIC DESCRIPTIONS

1. ORTHOCERAS GASPENSE Foerste, n. sp.

Plate 55, figures 10, 11

The holotype consists of a living chamber 15 mm. long laterally, the septum at its base having a convexity of 5 mm. when viewed from beneath. The diameter of this chamber increases from 12.5 mm. at its base to 13.8 mm. at its top. The passage of the siphuncle through the septum equals 1 mm. and its location is central. The surface of the cast of the interior of the chamber is marked by faint transverse markings too faint and irregular in location to suggest affinities either with *Geisonoceras* or *Geisonocerina*.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8879.

EXPLANATION OF PLATE 54

N.M.C., National Museum of Canada.

FIGS. *1, 2—Diestoceras gaspense* Foerste, n. sp., dorsal view, and lateral view with ventral outline on right; holotype, N.M.C. 8897. (p. 381)

3–5—Diestoceras brevidomum Foerste, n. sp., dorsal view, lateral view with ventral outline on left, and view from above showing outline of aperture with hyponomic angulation directed upward; holotype, N.M.C. 8899. (p. 383)

6—Diestoceras subglobosum Foerste, n. sp., lateral view with ventral outline on left; holotype, N.M.C. 8900. See also Pl. 55, fig. 2. (p. 383)

All figures reduced one-twentieth; all from Grande Coupé.

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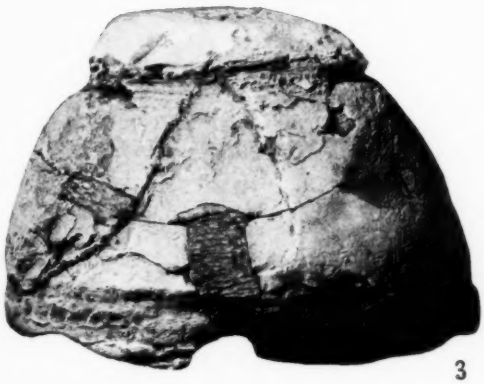

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2. ORTHOCERAS PERCENSE Foerste, n. sp.

Plate 55, figures 12, 13

The holotype is 29 mm. long, 14.5 mm. of this length belonging to the living chamber. It has been compressed dorsoventrally. Its maximum diameter enlarges from 16.5 mm. near its base to 19 mm. at its top in a length of 22 mm., the the angle of enlargement being about 9°. The minimum diameter at its top is 16 mm. Seven camerae are preserved and these shorten from 3 camerae in a length of 7 mm. at the lower end of the specimen to 2 in a length of 4 mm. at the top. The sutures of the septa slope moderately downward in a ventrad direction. The uppermost suture curves rapidly downward laterally so that the uppermost camera shortens from 2 mm. on its dorsal side to 0.8 mm. ventrally. The upper part of the cast of the interior of the living chamber, for a length of 8 mm., is faintly constricted, suggesting a slight annular thickening of the interior of the shell along the upper part of this chamber.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8880.

3. ORTHOCERAS KINDLEI Foerste, n. sp.

Plate 55, figure 14

The holotype is part of a phragmacone 30 mm. long. It has been compressed laterally. Its maximum diameter enlarges at an angle of almost 8° from 11.5 mm. at its base to 14.5 mm. at a point 20 mm. farther up. The camerae enlarge slowly in length from 3 in a length of 8 mm. at its base to 3 in a length of 8.5 mm. at its top. The sutures of the septa are straight and directly transverse. The cast of the interior of each camera is slightly constricted by a faint transverse groove slightly above its midlength. There also are traces of very faint vertical ribs, about 5 in a width of 4 mm. Parts of the surface show traces of minute transverse and vertical lines, producing a cancellated network, 10 vertical lines occurring in a length of 1 mm. and about 7 or 8 transverse lines in a width of 1 mm. Possibly this cancellated network is connected with structure of the interior of the shell rather than with its surface features. There is no trace of the siphuncle.

Occurrence: Grand Coupé, east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8881.

4. GEISONOCERAS EXPANSUM Foerste, n. sp.

Plate 55, figure 1

The holotype is 122 mm. long, 96 mm. of this length belonging to the living chamber. The conch is strongly flattened by pressure, its maximum diameter enlarging from 39 mm. near its base to 44.5 mm. at its top, 90 mm. farther up. At this top the minimum diameter, in its present condition, is 22.5 mm. The upper 5 camerae occupy a total length of 22 mm. The sutures of the septa originally were directly transverse. This is true also of the transverse bands, which are weakly indicated on the cast of the interior of the conch. Ten bands occur in a length of 14 mm. at the lower end of the specimen, increasing to 10 bands in a length of 20 mm. farther up.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8882.

DONACOCERAS Foerste

Genotype: *Donacoceras arundineum* Foerste, in Hume, G. S., Palaeozoic outlier of Lake Timiskaming, Ontario and Quebec: *Geol. Survey Canada Mem.*, 145, p. 69, pl. 10, fig. 4*B*, 1925.

Orthoceroids known only from their siphuncles. The segments of the siphuncle enlarge only slightly within the camerae. The septal necks apparently are short and their lower margins curve only slightly outward. The interior of the siphuncle apparently is free of organic deposits, or the latter are confined to a thin layer on its interior.

5. DONACOCERAS PERCENSE Foerste, n. sp.

Plate 55, figure 9

Siphuncle 103 mm. long, enlarging within this length from a diameter of 14.5 mm. at its lower end to 17 mm. at its top. Segments enlarging in length from 9 mm. at its lower end to 16 mm. at its top. At midlength, where one of its segments is 15.5 mm. in maximum diameter, it narrows to 14 mm. at the septal necks. The fourth segment from the base is conspicuously shorter than the rest.

Occurrence: In a coarsely conglomeratic limestone, Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8883.

Remarks.—From typical *D. arundineum* this siphuncle differs in the more rapid enlargement of its segments both in length and diameter.

6. METASPYROCERAS KINDLEI Foerste, n. sp.

Plate 56, figures 3–5; plate 57, figures 1–3

The holotype is 22 mm. long and consists of 3 camerae, each 6.5 mm. long, beneath which is a small part of a fourth camera. The conch has been compressed in its present condition the maximum diameter at its top is estimated at 20 mm., the minimum one being 14 mm. The crests of 8 annulations occur in a length of 17.5 mm., indicating about 9 annulations in a length equal to the maximum diameter of the conch. Around three-fourths of the circumference of the conch these annulations are directly transverse, but along the assumed ventral side of the latter they rise distinctly. The sutures of the septa, on the contrary, are approximately straight and slope downward in a ventrad direction for a vertical distance of 3 mm. The elevation

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EXPLANATION OF PLATE 55

N.M.C., National Museum of Canada.

FIGS. *1*—*Geisonoceras expansum* Foerste, n. sp., lateral view; the relatively narrow transverse bands are too faint to show unless illuminated at a strong angle to their length; holotype, N.M.C. 8882. (p. 375)

2—*Diestoceras subglobosum* Foerste, n. sp., dorsal view; holotype, N.M.C. 8900. See also Pl. 54, fig. 6. (p. 383)

3, 4—*Diestoceras cooperi* Foerste, n. sp., ventral view, and lateral view with ventral outline on right; holotype, N.M.C. 8898. (p. 382)

5–7—*Schuchertoceras logani* (Cooper), hypotypes. *5*, Lateral view with dorsal outline on left, showing lateral margin of septum forming its base; several millimeters higher is a suture held in common by several septa that are discrete dorsally and ventrally, only one of the strongly elevated dorsal saddles being well exposed; *6*, ventral view, tilted to show sutures on ventral side; passage of the siphuncle through the septum is visible, owing to the tilting, just above lower margin of figure; N.M.C. 8889. *7*, Lateral view with dorsal outline on left, showing three elevated dorsal saddles; N.M.C. 8889*a*. (p. 379)

8—*Neumatoceras* sp., lateral view with ventral outline on left, showing the strong contraction of the upper part of the conch toward the aperture, beginning about three camerae beneath the living chamber; N.M.C. 8895. (p. 381)

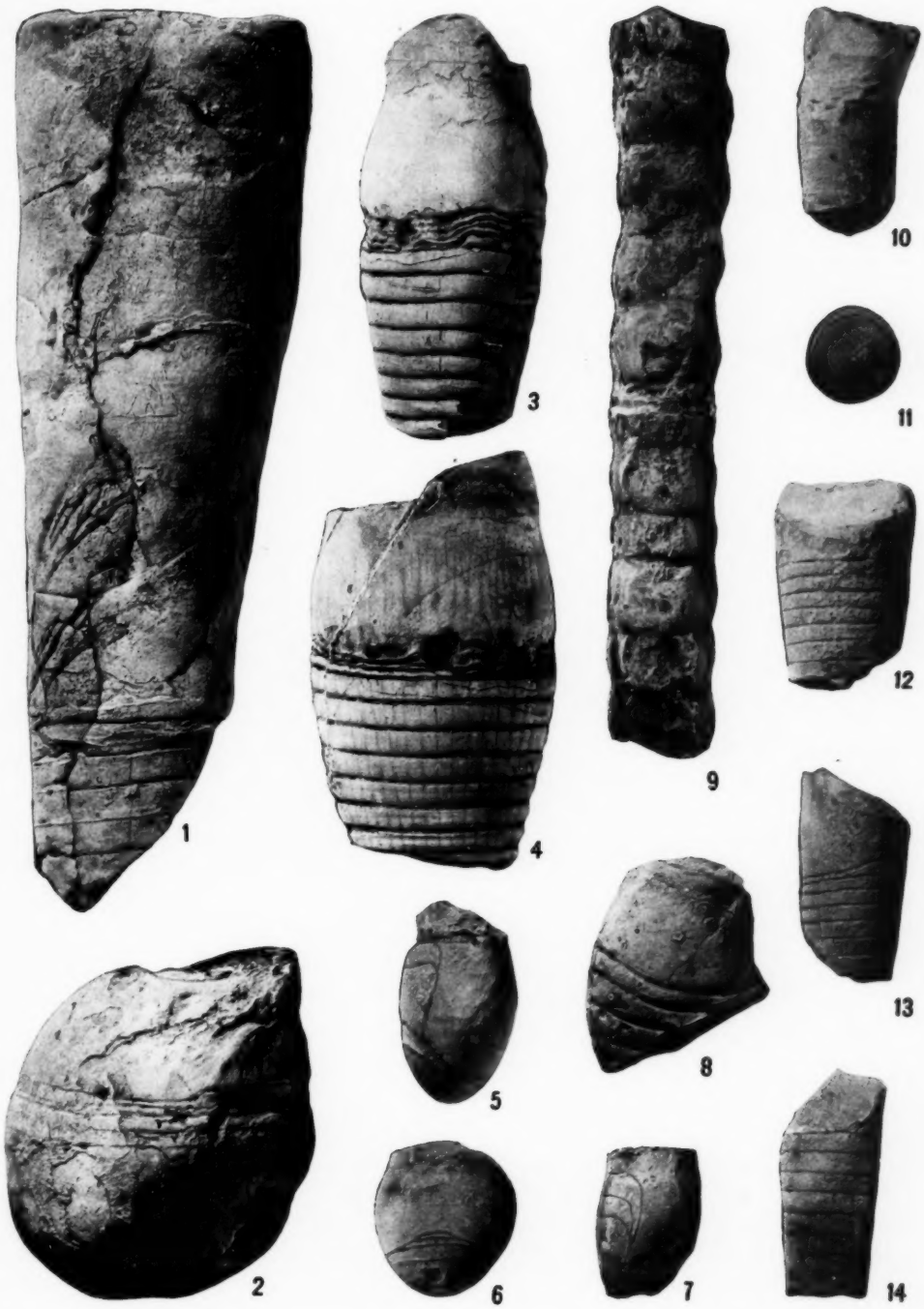
9—*Donacoceras percense* Foerste, n. sp., siphuncle only, apparently with segments of irregular length, but this may be due in part to imperfect preservation; holotype, N.M.C. 8883. (p. 376)

10, 11—*Orthoceras gaspense* Foerste, n. sp., lateral view of living chamber, and basal view showing location of siphuncle; holotype, N.M.C. 8879. (p. 374)

12, 13—*Orthoceras percense* Foerste, n. sp., dorsal view, and lateral view with ventral outline on left; holotype, N.M.C. 8880. (p. 375)

14—*Orthoceras kindlei* Foerste, n. sp., lateral view, with very faint traces of vertical markings as in *Polygrammoceras*, possibly belonging to that genus; holotype, N.M.C. 8881. (p. 375)

All specimens natural size; all from Grande Coupé.



Foerste, Ordovician Cephalopods

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of these annulations above the intermediate grooves is slightly less than half a millimeter. The surface of the shell is finely cancellated by vertical and transverse lines, the former being more prominent. Where these vertical lines alternate in size there are 7 of the more prominent lines in a width of 2 mm. The transverse lines number about 7 or 8 in a length of 1 mm. (Pl. 56, fig. 5; pl. 57, fig. 2).

A second specimen, 19 mm. long, is regarded as the upper part of a living chamber. The lower 3 annulations occur at about the same intervals as in the preceding specimen, but the overlying ones are more distant and the conch here contracts, as in other species referred to *Metaspyroceras*. The vertical raised lines are preserved best along the median parts of the dorsal and ventral sides of the conch, while the transverse lines dominate laterally. This may be due in part to weathering (Pl. 56, fig. 4; pl. 57, fig. 1).

A third specimen, 36 mm. long, appears to be confined to the living chamber. At its base its maximum diameter is 21.2 mm. and its lateral one is about 18 mm. It enlarges to only 22 mm. at its top. Eight annulations occur within a length equal to its maximum diameter. Apparently there is a contraction at the top of the specimen similar to that found at the upper end of the living chamber of species referred to *Metaspyroceras*. Locally the surface of the shell preserves distinct vertical raised lines. Where these are subequal there are 9 to 11 lines in a width of 2 mm. In other and more extensive areas there are numerous transverse incised lines or striae, numbering 8 or 9 in a length of 1 mm., and corresponding apparently to the raised transverse lines on the surface of the shell. Where these transverse striae dominate, the surface of the shell apparently is more weathered (Pl. 56, fig. 3; pl. 57, fig. 3).

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Types: Holotype, Nat. Mus. Canada 8884; paratypes, Nat. Mus. Canada 8884*a*,*b*.

Remarks.—The reference of this specimen to *Metaspyroceras* is based chiefly on the strong downward slope of the sutures of the septa in a direction assumed to be ventrad.

7. Metaspyroceras gaspense Foerste, n. sp.

Plate 56, figure 6; plate 57, figure 4

The holotype consists of part of a living chamber preserved for a length of 35 mm. It is slightly curved lengthwise, the convex outline being assumed to be ventral. The surface of this chamber is conspicuously annulated, the annulations being relatively distant from each other. Beginning with the annulation at the extreme base of its ventral outline the intervals between successive crests equal 6.5, 9.0, 8.0, and 8.5 mm. in ascending order. The more conspicuous annulations rise fully 1 mm. above the intermediate grooves, but the fourth annulation from the bottom is sufficiently less prominent to suggest an annular thickening of the interior of the shell along the upper part of the living chamber. On the dorsal side of the chamber the annulations rise only slightly in a ventrad direction, but on the ventral side this rise is much more conspicuous. Two small patches of the shell remain. These are vertically ribbed, the larger ribs being about 1 mm. apart. Judging from markings on the cast of the interior of the shell, there may have been also single intermediate vertical raised lines. There are also transverse raised lines. Corresponding transverse incised lines or striae on the cast of the interior of the chamber number from 7 to 9 in a length of 1 mm.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8885.

8. Spyroceras percense Foerste, n. sp.

Plate 56, figure 1; plate 57, figure 5

Conch represented by a fragment 24 mm. long and estimated to have been

about 13.5 mm. in diameter. The crests of the annulations vary in number from 4 in a length of 10 mm. to 4 in a length of 11 mm. Their elevation above the intermediate grooves slightly exceeds half a millimeter. The more prominent vertical ribs number about 6 in a width of 4.7 to 5 mm., indicating from 42 to 45 ribs within the circumference of the conch. Alternating with these more prominent ribs are single much narrower and less conspicuous vertical raised lines. The transverse lines tend to be relatively distant from each other, the intervals separating them equalling about 0.5 mm. on the annulations but frequently equalling 1 mm. in the intermediate grooves, and apparently becoming obsolete here locally.

Occurrence: Along the shore a mile and a half southwest of Percé and a quarter of a mile north of Whitehead lighthouse, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8886.

Remarks.—This specimen is characterized by the distinct alternation in prominence of the vertical ribs and raised lines and by the relatively long distance between the transverse raised lines. At least the transverse lines are distant when examined macroscopically in the present state of preservation of the specimen.

9. SPYROCERAS LIRATUM Foerste, n. sp.

Plate 56, figure 2; plate 57, figure 6

The holotype is 35 mm. long and enlarges in diameter from 16.5 mm. near its base to 18.5 mm. at a point 25 mm. farther up. The number of crests of annulations ranges from 4 in a length of 11.5 mm. along the lower half of the

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EXPLANATION OF PLATE 56

N.M.C., National Museum of Canada.

FIGS. 1—*Spyroceras percense* Foerste, n. sp., lateral view showing alternating vertical ribs and relatively distant transverse lines; holotype, N.M.C. 8886. See also Pl. 57, fig. 5. (p. 377)

2—*Spyroceras liratum* Foerste, n. sp., lateral view of conch apparently consisting of living chamber with two camerae at base; holotype, N.M.C. 8887. See also Pl. 57, fig. 6. (p. 378)

3–5—*Metaspyroceras kindlei* Foerste, n. sp. *3*, Lateral view of conch; paratype, N.M.C. 8884*b*; see also Pl. 57, fig. 3. *4*, Lateral view of conch; paratype, N.M.C. 8884*a*; see also Pl. 57, fig. 1. *5*, Lateral view of holotype, N.M.C. 8884; see also Pl. 57, fig. 2. (p. 376)

6—*Metaspyroceras gaspense* Foerste, n. sp., lateral view with ventral outline on left, showing contraction of living chamber toward aperture, and the slightly convex curvature of the ventral outline; holotype, N.M.C. 8885. See also Pl. 57, fig. 4. (p. 377)

7—*Spyroceras? subglabrum* Foerste, n. sp., lateral view of conch; surface of shell without trace of surface markings; holotype, N.M.C. 8888. (p. 379)

8—*Apsidoceras* sp., ventrolateral angle of conch, with ventral side on right, showing strongly elevated ventrolateral saddles, N.M.C. 8890. (p. 379)

9—*Ooceras?* sp., lateral view of phragmacone showing siphuncle on right; on the side of the siphuncle facing the interior of the conch the septal necks originally were coated with a thicker deposit of calcite than on the side facing the exterior; N.M.C. 8896. (p. 381)

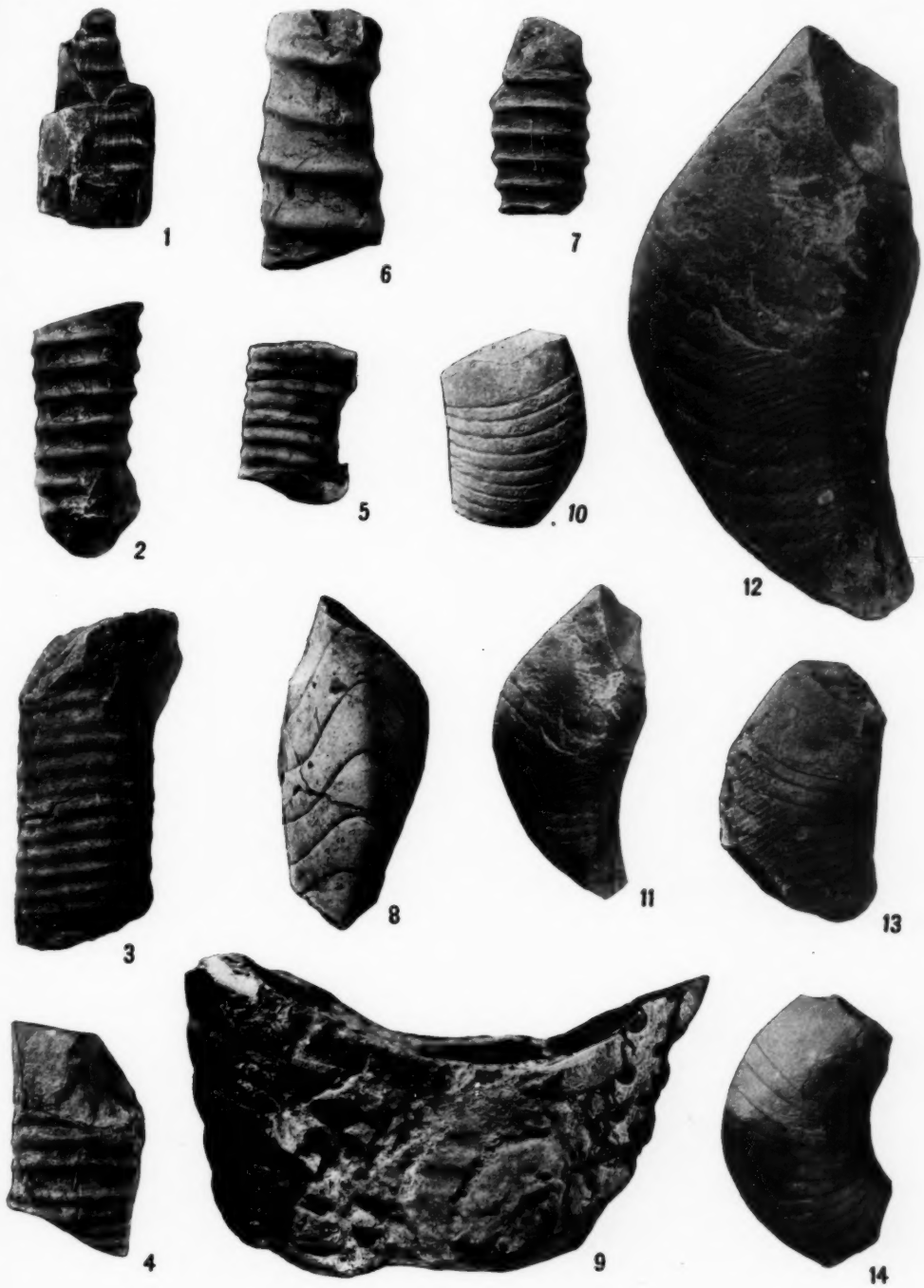
10—*Beloitoceras* sp., lateral view with ventral outline on right; N.M.C. 8891. (p. 380)

11, 12—*Neumatoceras striatum* Foerste, n. sp., lateral view, ×1 and ×2, with ventral outline on left, showing traces of narrow transverse lines curving downward ventrally; holotype, N.M.C. 8893. (p. 380)

13—*Neumatoceras latilineatum* Foerste, n. sp., lateral view with much broader transverse markings of the type called "banded"; holotype, N.M.C. 8892. (p. 380)

14—*Neumatoceras percense* Foerste, n. sp., lateral view with ventral outline on left (partly restored); holotype, N.M.C. 8894. (p. 380)

All figures natural size except fig. *12*, which is ×2; fig. *1*, a quarter of a mile north of Whitehead Lighthouse; figs. *2–14*, Grande Coupé.



Foerste, Ordovician Cephalopods

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specimen to 4 in a length of 12.5 mm. farther up. There are from 8 to 10 vertical ribs in a width of 5 mm. These are about equal in width and prominence, the intermediate spaces being flat. Intermediate vertical lines are either absent or only obscurely indicated. In a similar manner, transverse raised lines are either absent or only faintly indicated.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8887.

Remarks.—*S. liratum* differs from *S. percense* chiefly in the absence of conspicuous alternation in the prominence of the vertical ribs and intermediate raised lines.

10. SPYROCERAS? SUBGLABRUM Foerste, n. sp.

Plate 56, figure 7

The holotype is 21 mm. long and enlarges slightly within this length. Its maximum diameter is 14 mm. at midlength. Apparently the conch is faintly curved lengthwise. The intervals between the crests of the annulations increase from 3.5 mm. at the lower end of the specimen to 5 mm. at its top. These crests are narrow and prominent, rising fully 1 mm. above the intermediate grooves at the top of the specimen. The surface of the shell on casual examination appears smooth, but careful search with a magnifier reveals scanty traces of vertical markings, about 6 in a width of 2.75 mm., which look like weathered remains of vertical ribs. It will require better preserved specimens to establish the presence of these ribs and their relative number beyond all doubt.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8888.

11. SCHUCHERTOCERAS LOGANI Cooper

Plate 55, figures 5–7

Billingsites logani COOPER, *1930*, Am. Jour. Sci., ser. 5, vol. 20, p. 287, pl. 3, figs. 7–10.
Schuchertoceras logani A. K. MILLER, *1933*, Am. Jour. Sci., ser. 5, vol. 26, p. 182.

Specimens closely similar to the holotype. One of these shows the margin of the septum at its base fairly distinctly. It rises in a dorsad direction at an even rate from a level of 2 mm. above the base of the specimen ventrally to a point 8.5 mm. above this base dorsally. Along the median part of the ventral side of the specimen there are three discrete sutures at distances of 2, 3, and 3.8 mm. above the lowest part of the margin of the basal septum. These three sutures coalesce laterally at points about 5 mm. from the median part of the ventral side and then diverge again farther up on the erect part of the dorsal saddles. The second specimen here figured shows three distinct dorsal saddles.

Occurrence: In very fine-grained dark gray limestone, Grande Coupé, at east end of Gaspé Peninsula.

Types: Holotype, Peabody Mus. (Yale Univ.) 12922; hypotypes, Nat. Mus. Canada 8889,*a*.

12. APSIDOCERAS DEPRESSUM Cooper

Apsidoceras depressum COOPER, *1930*, Am. Jour. Sci., ser. 5, vol. 20, p. 286, pl. 3, figs. 11–14.

This species is characterized by the strong dorsoventral depression of the conch, and the moderate depth of the ventral lobes of the sutures of the septa.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Peabody Mus. (Yale Univ.) 12921.

13. APSIDOCERAS sp.

Plate 56, figure 8

Several fragments of a species of *Apsidoceras* occur, in which the ventrolateral saddles of the sutures of the septa are much more strongly elevated, the intermediate ventral lobes being correspondingly deeper. The dorsoventral diameter of the conch is relatively greater, resulting in a subtriangular cross section. Unfortunately these fragments are not sufficient for an adequate description of this species.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Figured specimen: Nat. Mus. Canada 8890.

14. BELOITOCERAS sp.

Plate 56, figure 10

The specimen here figured is of interest chiefly in showing the presence of the genus *Beloitoceras* in the Gaspé area. Compared with typical *Neumatoceras* the conch is much less curved lengthwise both dorsally and ventrally, and the contraction of the living chamber toward the aperture is much less conspicuous. There are faint traces of vertical ribs on the sides of the cast of the interior of the phragmacone and at the base of the cast of the interior of the living chamber there is a transverse series of shallow pits, 5 in a width of 8.5 mm. The latter indicate the presence of a low annular thickening of the shell along the base of the walls of the conch surrounding this chamber, apparently 1 mm. in vertical width. This ring is supposed to have served for the attachment of the basal part of the animal to the interior of the conch. Similar attachment areas are common in species of *Phragmoceras*, *Cyrtogomphoceras*, and numerous other cyrtoconic genera.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Figured specimen: Nat. Mus. Canada 8891.

15. NEUMATOCERAS LATILINEATUM Foerste, n. sp.

Plate 56, figure 13

The holotype is 35 mm. long, about 15 mm. of this length belonging to the living chamber. Its maximum dorsoventral diameter apparently was at about the fourth camera beneath the living chamber ventrally and is estimated at 23 mm. From here the conch contracted to 20 mm. at the base of the living chamber and to 17 mm. at the aperture. The dorsal outline was only slightly concave for a length of 15 mm. along the lower part of the living chamber and the adjacent part of the phragmacone. The ventral outline is assumed to have been geniculate at the fourth camera mentioned above. The sutures of the septa curve strongly downward laterally, rising higher ventrally than dorsally. The most distinctive feature of this species is the width of the transverse bands. These curve increasingly downward from the dorsal toward the ventral side of the conch, 5 occurring in a length of 5.5 mm. along the lower part of the ventral side, but becoming more crowded toward the dorsal side of the conch and toward the aperture.

Occurrence: Grand Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8892.

16. NEUMATOCERAS STRIATUM Foerste, n. sp.

Plate 56, figures 11, 12

The holotype is about 40 mm. long and is estimated to have had a dorsoventral diameter of about 20.5 mm. at the base of the third camera beneath the living chamber. In general this specimen is closely similar to the holotype of *Neumatoceras latilineatum* in size and structure, but its dorsal outline is distinctly more concave, having a radius of curvature of 30 mm. in a concave direction. The most characteristic feature of this conch is its relatively close transverse striation, 10 distinct transverse raised lines occurring in a length of 4 mm. along the lower part of the conch, changing to 10 in a length of 6 mm. at midlength.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8893.

17. NEUMATOCERAS PERCENSE Foerste, n. sp.

Plate 56, figure 14

The holotype is 40 mm. long in a direct line, but 50 mm. long when measured along its ventral outline. The original length of the living chamber was at least 15 mm. laterally. The most characteristic feature of this species is its strong lengthwise curvature, the radius of concave curvature of its dorsal outline being about 15 mm. Its maximum dorsoventral

diameter at the base of the fourth camera beneath the living chamber is estimated at 21 mm. From this it shortens to about 15 mm. at the aperture. The sutures of the septa, as usual in this genus, curve strongly downward laterally and rise higher ventrally than dorsally. There is no trace of surface markings.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8894.

18. NEUMATOCERAS sp.

Plate 55, figure 8

Compared with the other specimens of *Neumatoceras* described here this conch is larger dorsoventrally. It is of interest chiefly because it shows distinctly the upward contraction of the conch from the third or fourth camera below the living chamber ventrally as far as the aperture.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Figured specimen: Nat. Mus. Canada 8895.

19. OOCERAS? sp.

Plate 56, figure 9

This specimen is of interest chiefly in showing the bizarre appearance presented by the interior of certain cyrtochoanitic siphuncles when the calcareous deposits on the inner surface of septal necks and some of the adjacent material is replaced by ferruginous or other material, as in the vertical section of *Ooceras seelyi* and *O. lativentrum* figured by Ruedemann from the Chazyan of Isle La Motte and Valcour Island in Lake Champlain.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Figured specimen: Nat. Mus. Canada 8896.

20. DIESTOCERAS GASPENSE Foerste, n. sp.

Plate 54, figures 1, 2

The holotype is 62 mm. long, the living chamber occupying 46.5 mm. of this length. The dorsal side is more erect and the ventral side slants more distinctly inward. At the base of the specimen the maximum dorsoventral diameter is 74 mm. and the lateral diameter is 58 mm., the latter being located between the two camerae at its base. From this point the conch contracts rather evenly toward the aperture, the maximum diameter here being about 56 mm. and the lateral one about 36 mm. At the base of the cast of the interior of the living chamber there is a shallow groove about 6 or 7 mm. long vertically. Within this groove there are faint traces of vertical ribs and intermediate depressions. Originally the basal part of the inner surface of the shell surrounding the living chamber was thickened into an annular zone probably serving for the attachment of the animal to the interior of the conch. At the top of the cast of the interior of the living chamber there is a much longer contracted zone, from 10 to 15 mm. in length, not sharply defined from the underlying part of this chamber, but more distinctly delimited at its top which, dorsolaterally at least, is a short distance beneath the aperture. Evidently the interior of the shell surrounding the living chamber was thickened by an organic deposit toward the aperture as well as at the base of the chamber, the upper annular area serving to strengthen the shell here. The uppermost camera is 6 mm. long, the one directly beneath is 8 or 9 mm. long. The sutures of the septa are almost straight and directly transverse, except dorsally where they rise slightly, forming low subangular saddles. The siphuncle is exposed within the second camera beneath the living chamber. Here its maximum diameter is 8.5 mm., its vertical outlines being only moderately convex, but at top and bottom the segment contracts abruptly to a diameter of about 4 mm., the septal necks being short and cyrtochoanoidal. The distance of the siphuncle from the ventral wall of the conch is 1 mm.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8897.

21. DIESTOCERAS COOPERI Foerste, n. sp.

Plate 55, figures 3, 4

The holotype is 57 mm. long, 26 mm. of this length belonging to the living chamber. Its dorsoventral diameter enlarges from 25 mm. near its base to 35.5 mm. at the base of the living chamber, and then contracts to 30 mm. at the aperture. The corresponding lateral diameters are 20 mm., 27.2 mm., and 21 mm. The dorsal outline is more evenly convex, while the ventral outline is straighter along the phragmacone and tends to be subangular at the base of the living chamber. The cast of the interior of the conch contracts along the upper half of the living chamber, indicating an annular thickening of the interior of the conch here for a vertical length of 6 or 7 mm.; the lower margin of this thickening is indistinct but its upper margin is distinctly delineated and is 5 to 7 mm. beneath the aperture. The camerae increase slowly in length from 3 mm. at the base to 3.5 mm. at the seventh camera, the eighth camera being 3 mm. long, but the following 4 shorten to a total length of 5.5 mm., thus indicating striking gerontic conditions. The cast of the interior of the phragmacone is ribbed vertically, the ribs being broad and low but fairly distinct. They continue upward along the lower half of the living chamber as faint extensions. The sutures of the septa curve downward laterally, producing subangular saddles, the dorsal ones rising slightly higher than the ventral. The siphuncle is about half a millimeter distant from the ventral wall of the conch at the base of the specimen. Its diameter here is approximately 3 mm., contracting abruptly to 1 mm. at its passage through the septum, the septal neck being short and cyrtochoanoidal. The surface of the cast of the interior of the conch shows traces of transverse markings suggesting the presence of correspondingly straight and directly transverse markings on the surface of the shell.

Occurrence: Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8898.

Remarks.—*D. cooperi* is closely similar in form and structure to the holotype of *D. vagum* Foerste (3), from the English Head formation of Anticosti, but the conch is smaller, the maximum downward curvature of the sutures of the septa is nearer the middle of the lateral sides, resulting in a longer rise of these sutures in a dorsad direction. The vertical ribbing on the cast of the interior of the conch and the contraction of this cast along the upper half of the living

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EXPLANATION OF PLATE 57

N.M.C., National Museum of Canada.

FIGS. *1–3*—*Metaspyroceras kindlei* Foerste, n. sp., surface markings, ×6. *1*, Paratype, N.M.C. 8884*a*; see also Pl. 56, fig. 4. *2*, Markings apparently weakened by weathering; holotype, N.M.C. 8884; see also Pl. 56, fig. 5. *3*, Markings assumed to belong to inner layer of shell and to correspond to the transverse markings of Pl. 56, fig. 4; paratype, N.M.C. 8884*b*. (p. 376)

4—*Metaspyroceras gaspense* Foerste, n. sp., surface markings, ×6, of holotype, N.M.C. 8885, shown in Pl. 56, fig. 6. The vertical markings on the small patch of shell still preserved belong to the exterior surface; the transverse markings seen at various levels belong to one of the inner layers of the shell; similar differences are shown in *M. kindlei*, figs. 1–3. (p. 377)

5—*Spyroceras percense* Foerste, n. sp., surface markings, ×3, of holotype, N.M.C. 8886, shown in Pl. 56, fig. 1. The bilineate character of the vertical raised lines is distinct. (p. 377)

6—*Spyroceras liratum* Foerste, n. sp., surface markings, ×3, of holotype, N.M.C. 8887, shown in Pl. 56, fig. 2. The vertical raised lines are nearly equal in size; the intermediate spaces usually are free from vertical lines; the transverse lines are much finer, are preserved locally, and are not seen in the figure. (p. 378)

Figs. *1–4*, *6*, Grande Coupé; fig. *5*, a quarter of a mile north of Whitehead Lighthouse.

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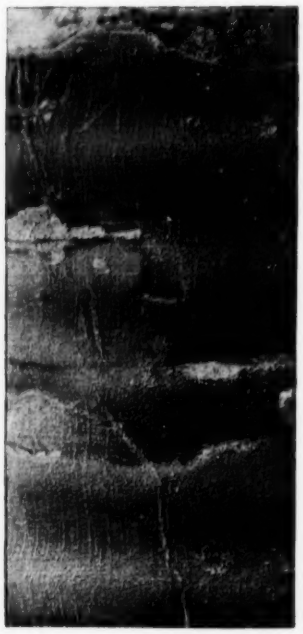

2

3

4

5

6

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chamber are other distinctive features. The gerontic shortening of the upper 4 camerae probably is an individual characteristic, not to be expected in other individuals of this species.

22. DIESTOCERAS BREVIDOMUM Foerste, n. sp.

Plate 54, figures 3–5

Conch represented only by the living chamber. The latter is 40 mm. long, with a lateral diameter of 70 mm. and a dorsoventral one of 65 mm. at its base. Its dorsal side is flattened, resulting in a slightly triangular cross section, most conspicuous at the aperture. Its dorsal outline is much steeper than its ventral one. The chamber is strongly constricted toward the aperture, the latter having a lateral diameter of 39 mm. and a dorsoventral one of 37 mm. The general form of the aperture is subtriangular, with the narrowest angle on its ventral side, the latter indicating the location of the hyponomic sinus. The cast of the interior of this chamber is constricted by an annular groove both at its base and at its top. The groove at its base is between 2 and 3 mm. in vertical height, is relatively shallow, and is occupied by a series of subquadrangular shallow pits, 5 of these occurring in a width of 18 mm. This groove indicates the presence of an annular thickening on the interior of the shell at the base of the living chamber, possibly serving as an attachment area for the marginal part of the animal at its base. The groove at the top of the cast of the interior of the living chamber indicates a similar annular thickening of the interior of the shell, between 4 and 5 mm. in vertical height and about 2 mm. in thickness. It evidently served to strengthen the shell at its aperture. Along the dorsolateral side of the chamber the shell is about 0.75 mm. thick, thinning toward the aperture, except at the annular ring just described. Along the lower half of this dorsolateral side 5 low transverse annulations occur in a length of 9 mm. Just beneath the aperture these annulations become much more crowded, 5 occurring in a length of 4.5 mm.

Occurrence: In a very fine-grained dark gray limestone, Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8899.

Remarks.—The living chamber of *D. brevidomum* resembles that of *D. arenicolum* Foerste (*3a*), from the Ellis Bay formation of Anticosti, in its relatively short length, the steepness of its dorsal outline and the low slope of its ventral outline. However, its lateral diameter is relatively broader, its dorsal side being flatter, resulting in a subtriangular outline.

23. DIESTOCERAS SUBGLOBOSUM Foerste, n. sp.

Plate 54, figure 6; plate 55, figure 2

The holotype is between 50 and 52 mm. long, about 22 mm. of this length belonging to the living chamber. The lateral walls of the phragmacone are preserved for a length of 20 mm., beneath which a septum is exposed with a convexity of 13 mm. when viewed from beneath. The specimen evidently is distorted. In its present condition the maximum transverse diameter is 56 mm., the minimum one being 65 mm. The general appearance of the specimen is subglobose, the convexity of the septum at its base not being sharply delimited from that of the lateral walls of the phragmacone. Here the maximum diameter of the septum is 48 mm. and the minimum is about 37 mm. The living chamber also appears to contract in a globose manner, toward the aperture, the latter having a maximum diameter of 27 mm. and a minimum one of 18.5 mm. in its present condition. The general form of this aperture is oval with its narrower end facing in the direction of the longer diameter of the conch, and apparently corresponding to the hyponomic sinus. Apparently there is a trace of the siphuncle at the margin of the septum at the base of the specimen, directly beneath the supposed

hyponomic sinus. If this interpretation is correct, the specimen has been compressed somewhat obliquely in a lateral direction. The cast of the interior of the living chamber is characterized along its basal margin by a distinct groove about 3 mm. in height vertically. This groove is occupied by subquadrangular shallow pits, 5 of these in a width of 15 mm. This groove indicates the former presence of an annular thickening of the basal part of the shell surrounding the living chamber and possibly served for the attachment of the lower part of the animal to the interior of the conch. The uppermost camera is exposed for a length of 1 mm., that directly beneath being 3 mm. long. The underlying part of the phragmacone, 18 mm. long, apparently consisted of only 2 camerae, but this is not certain.

Occurrence: In a very fine-grained dark gray limestone, Grande Coupé, at east end of Gaspé Peninsula.

Holotype: Nat. Mus. Canada 8900.

Remarks.—D. subglobosum apparently is similar in form and structure to *D. schucherti* Foerste (4) from the Trenton at the head of Frobisher Bay in southern Baffin Land, in the American Arctic. This similarity is due chiefly to the strong convexity of the septa when viewed from beneath, and the tendency of the conch to lose the lower part of its phragmacone a relative short distance beneath the maximum transverse diameter of the conch, thus giving the part preserved a subglobose appearance.

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Note: The manuscript of this paper was received by the editor July 19, 1935. Owing to the regretted death of the author before the paper could be published, the proof has been read by others.

JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 5, PP. 385–387, 13 TEXT-FIGS., JULY, 1936

ORDOVICIAN GRAPTOLITES FROM QUEBEC AND TENNESSEE

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ABSTRACT

The genus *Marsipograptus* is proposed to receive two new species, one from the Whitehead formation of Percé, Quebec, one from the Ottosee shale of Tennessee.

It is the primary purpose of this paper to record two graptolites from the Whitehead formation of Percé, Quebec, but as one of the genera represented has been previously recorded only as a *nomen nudum* it is necessary to describe both the genus and its type species, the latter from Tennessee.

MARSIPOGRAPTUS Ruedemann, n. gen.

Etymology: *μάρσιπος*, a bag; *γραπτός*, written.

Dendroid graptolites with the structure of *Desmograptus*, to the branches of which are attached hemispheric to subspheric chitinous swellings considered homologous to the ooecia or ovicells of the bryozoans.

Genotype: *Marsipograptus bullatus* Ruedemann, n. sp.

MARSIPOGRAPTUS BULLATUS Ruedemann, n. sp.

Marsipograptus bullatus RUEDEMANN (*nomen nudum*), *1931*, Geol. Soc. Am., Bull., vol. 42, p. 599, fig. 11.

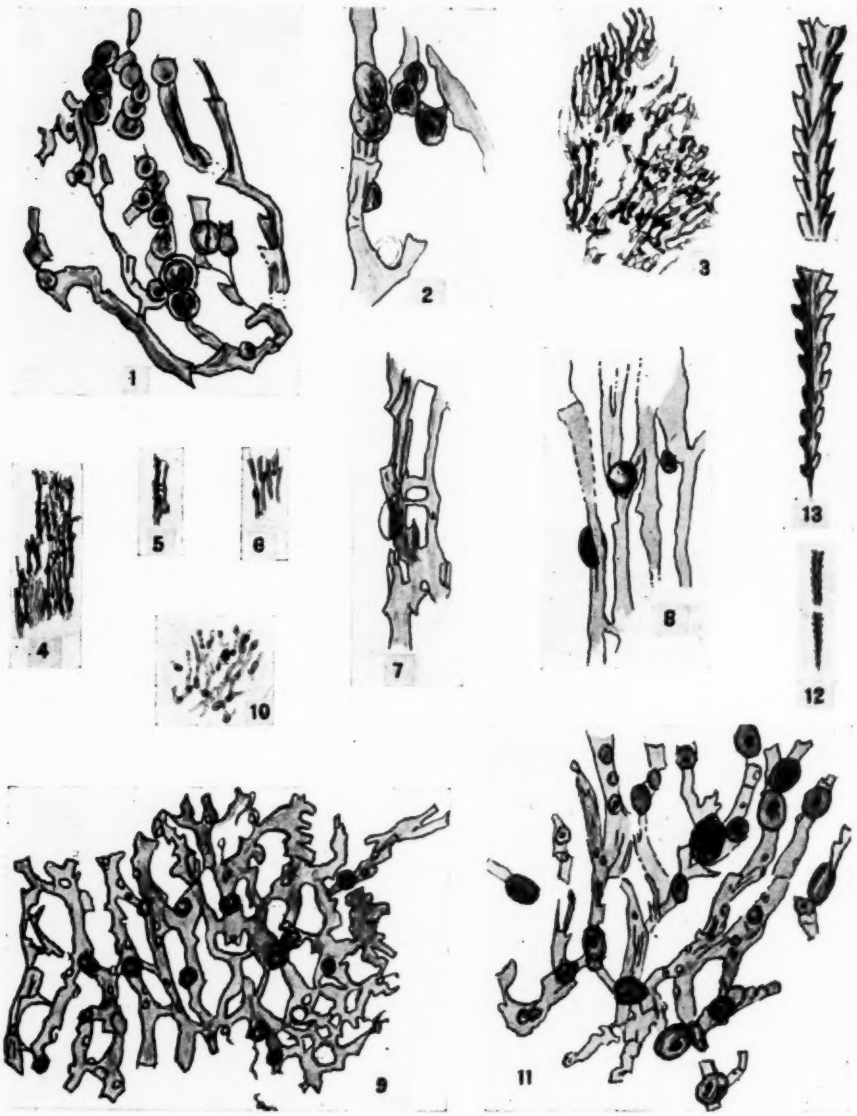
Rhabdosome of unknown size and shape, probably of medium size, bush-like or arboriform. Branches thin (0.25 mm.), irregularly undulating, frequently reuniting at the points of contact; or connected by stout, curved dissepiments, the dissepiments forming together a most irregular meshwork of, on the whole, oval meshes of various sizes, averaging 1 mm. in width, 1.5 mm. in length. Branches in 10 mm. across the rhabdosome, 13 to 15. Thecae rarely seen in profile, arranged on one side of branch, projecting at about 30°, with denticulate aperture, numbering 16 or more in 10 mm. The most striking feature of the species, which suggested its name, are subspherical swellings of the branches, about 0.5 mm. wide, irregularly distributed on the non-theciferous side.

Horizon and locality.—Rare in the Ottosee shale, at top of lower third, 6 miles south-southeast of Knoxville, Tennessee (U. S. Geol. Survey loc. 448x4).

MARSIPOGRAPTUS PERCENSIS Ruedemann, n. sp.

Figures 1–11

Rhabdosome probably fan-shaped, rapidly spreading, of small size (largest fragment, 40 mm. long, 18 mm. wide; another, 31 mm. long, 24 mm. wide). Branches straight in basal parts, undulating in other parts, giving some portions the aspect of *Dictyonema*, others that of *Desmograptus;* branches 0.4 to 0.8 mm. wide, numbering 10 in 10 mm., frequently dividing in the distal portions, with dissepiments forming a great variety of meshes—elongate-quadrangular in the portions with straight branches, ovate and elliptical in the portions where the branches anastomose; meshes 1.4 to 2.2 mm. long. Thecae not seen in profile or but little projecting, numbering 12 in 10 mm. Rhabdosome covered in some portions with subspherical appendages, probably ooecia or ovicells, averaging 0.6 mm. in diameter, but attaining 0.75 mm.;



FIGS. *1–11*—*Marsipograptus percensis* Ruedemann, n. gen. and sp., Whitehead formation, Grand Coupé, Percé, Quebec. *1–3*, Holotype, ×6 and ×1, Nat. Mus. Canada 8854. *4–8*, Paratype, U. S. Nat. Mus. 91806; *4–6*, ×1; *7–8*, ×6. *9*, Paratype, ×6, Nat. Mus. Canada 8854*a*. *10–11*, Paratype, ×1 and ×6, Nat. Mus. Canada 8854*b*. (p. 385)

12–13—*Mesograptus* sp., Whitehead formation, Amphitheater Road, Percé, Quebec, ×1 and ×6, U. S. Nat. Mus. 91827. (p. 387)

most frequent at the points of bifurcation.

Types: Holotype, Nat. Mus. Canada 8854; paratypes, Nat. Mus. Canada 8854,*a*,*b*, and U. S. Nat. Mus. 91806.

Locality: Grand Coupé, Percé, Quebec.

Discussion.—*M. percensis* is close to *M. bullatus* in size and general appearance, but differs in its thicker and more widely spaced branches, and probably in possessing fewer thecae in a given length. More complete material may show, however, that both forms fall within a single variable species.

MESOGRAPTUS sp.

Figures 12–13

A small form similar to *Mesograptus* (*Amplexograptus*) *macer* Ruedemann of the uppermost Canajoharie shale is probably not identical with it.

Figured specimen : U. S. Nat. Mus. 91827.

Locality: Amphitheater Road, Percé, Quebec.

Discussion.—The whole group of Diplograpti is not of much value for correlation of later Ordovician rocks, as it changes very little

JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 5, PP. 388–391, 2 TEXT-FIGS., JULY, 1936

A SUGGESTED NOMENCLATURE FOR THE CUSPS OF THE CHEEK TEETH OF RODENTS

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ABSTRACT

A terminology for the cusps of the cheek teeth of rodents, based as far as possible on homology and designed to conform to the tenets of the tritubercular theory, is offered as a basis for future work.

The terminology of the Tritubercular Theory has been applied to the cusps of the teeth of almost all mammals. Generally the names are assigned on the basis of known homologies, though sometimes they are used in a descriptive manner to indicate only the position of a cusp and without attempt to determine actual homology. The former is generally accepted as the more satisfactory method, and, whenever possible, should be followed.

One large order of mammals, the rodents, has certain characteristic patterns that seem to be founded on a few main cusps, and these cusps must needs be identified before much progress can be expected in the study of the evolution of the order. The patterns are frequently quite distinct from those found in other groups of mammals, a fact that has led to considerable confusion in the interpretation of the homologies of the cusps. Furthermore, there is so much parallelism within the order that the teeth must be studied in great detail, and names must be given to parts that in other groups would not be worth discussing.

Certain cusps of rodent teeth appear to be identifiable with a high degree of probability as the same as those found in other orders. To these the customary names have been applied. Others, of equal importance, cannot be so identified and must be given new names. Still others have been referred to by certain authors under names that appear to us to be positively misleading. Such, for example, is the frequent reference to the antero-internal cusp of the lower molars as a "paraconid," although the true parconid seems to have been lost in this order before the beginning of the Eocene. As has been pointed out by Frechkop (1*a*), the crests of rodent molars are never absolutely homologous with the similarly named crests of ungulates. There is not, we believe, likely to be any great confusion introduced by this lack of identity, but the fact of these differences should constantly be kept in mind. In the cricetid-like type of molars, either of two distinct

crests may develop in the region represented by each loph of ungulates. We have decided to give these crests names indicative of their derived nature, calling them "protolophule I," "protolophule II," etc. Positional names (such as antero-internal cusp) have often been used. Though this type of terminology has its use in describing cusps whose homologies are in doubt, it seems to us definitely to hamper progress where homologies are known or suspected. To a lesser extent this is true of the numerical terminology adopted by Winge (7) and followed by Hinton (2). Names such as "pseudo-metaconid" and "pseudo-metalophid" might be used, but suffer from the danger of being too unwieldy.

It is in the hope of clearing up some of the confusion and of forming a basis for future work by suggesting a uniform cusp terminology that we have presented the accompanying summary. We have been guided by the belief that the tritubercular system of nomenclature should be preserved as a nomenclature of homology, and that, hence, if two cusps have the same position and appearance but a different origin, they should bear distinct names. There is, of course, the danger that the literature will be encumbered with an almost infinite number of new names, proposed for every infinitesimal accessory cuspule, but we do not believe the danger to be great, since no one will use names that have been proposed if they do not serve a useful function. For rodents, at least, the method of development of the tooth pattern is so distinct from the method for other orders that, unless certain new names are adopted, there can be little hope for a fuller understanding of the phylogeny of the order.

The accompanying diagrams, Figs. 1 and 2, show the positions of the various cusps and crests and the terminology offered. A terminology for the valleys of rodent teeth that should prove very useful among the higher crowned members of the order has recently been suggested by Stirton (5).

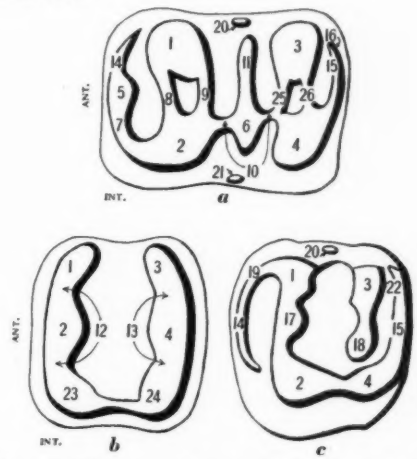

FIG. 1—Diagrams of upper left cheek teeth of rodents. *a*, Cricetid type of tooth. *b*, Heteromyid type of tooth. *c*, Sciuravid type of tooth. *Ant.*, anterior, *Int.*, lingual.

1. *Paracone* of authors.
2. *Protocone* of authors.
3. *Metacone* of authors.
4. *Hypocone* of authors.
5. *Anterocone.* A cusp derived from the anterior cingulum.
6. *Mesocone.* A cusp developed from the antero-posterior crest in the median valley. Schaub's "mesostyle" (4), Wood's "central cusp" (9).
7. *Anteroloph.* Anterior cingulum when elevated to form a crest equal in importance to the others.
8. *Protolophule I.* Crest from anterior end of the protocone to anterior end of the paracone.

9. *Protolophule II.* Crest from posterior end of the protocone to posterior end of the paracone.
10. *Mure* of authors. Schaub's "Längsgrat" (4).
11. *Mesoloph.* Crest from mesocone toward buccal or lingual margin of the tooth. This may or may not unite with the mesostyle or enterostyle or both. Schaub's "Mesostylsporn" (4).
12. *Protoloph* of authors.
13. *Metaloph* of authors.
14. *Anterior* cingulum of authors.
15. *Posterior* cingulum of authors.
16. *Posteroloph.* Posterior cingulum when elevated to form a crest equal in importance to the others.
17. *Protoconule* of authors.
18. *Metaconule* of authors.
19. *Parastyle* of authors.
20. *Mesostyle* of authors.
21. *Enterostyle.* Cusp blocking the lingual opening of the median valley.
22. *Metastyle* of authors.
23. *Protostyle* of Wood (8).
24. *Entostyle* of Wood (8).
25. *Metalophule I.* Crest from the anterior end of the metacone to the anterior end the hypocone.
26. *Metalophule II.* Crest from the posterior end of the metacone to the posterior end of the hypocone.

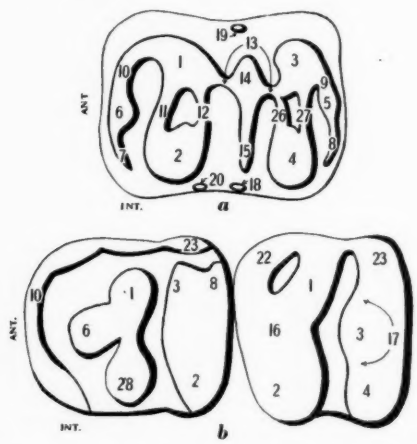

FIG. 2—Diagrams of lower right cheek teeth of rodents. *a*, Cricetid type of tooth. *b*, Heteromyid type of tooth. *Ant.*, anterior, *Int.*, lingual.

1. *Protoconid* of authors.
2. *Metaconid* of authors.
3. *Hypoconid* of authors.
4. *Entoconid* of authors.
5. *Hypoconulid* of authors.
6. *Anteroconid.* Cusp of the anterior cingulum (8). This is frequently called "paraconid" by authors.
7. *Anterior cingulum* of authors.
8. *Posterior cingulum* of authors.
9. *Posterolophid.* Posterior cingulum when elevated to form a crest equal in importance to the others.
10. *Anterolophid.* Anterior cingulum when elevated to form a crest equal in importance to the others.
11. *Metalophulid* I. Crest from anterior end of protoconid to anterior end of metaconid.
12. *Metalophulid* II. Crest from posterior end of protoconid to posterior end of metaconid.
13. *Ectolophid.* Crest from the protoconid to hypoconid, near the buccal side of the tooth. Schaub's "Längsgrat" (4).
14. *Mesoconid.* Cusp on the ectolophid in the median valley. Schaub's "Mesostylid" (4), Wilson's "hypostylid" (6), Wood's "central cusp" (9).
15. *Mesolophid.* Crest from mesoconid toward the lingual or buccal side of the tooth, which may unite with either the ectostylid or the mesostylid or both. Schaub's "Mesostylidsporn" (4).
16. *Metalophid* of authors.
17. *Hypolophid* of authors.
18. *Mesostylid.* Cusp at lingual end of median valley.
19. *Ectostylid.* Cusp at buccal end of median valley.
20. *Metastylid* of authors.
22. *Protostylid.* Cingulum cusp buccal to protoconid (8).
23. *Hypostylid.* Cingulum cusp buccal to hypoconid (9).
26. *Hypolophulid* I. Crest from anterior end of hypoconid to anterior end of entoconid.
27. *Hypolophulid* II. Crest from posterior end of hypoconid to posterior end of entoconid.
28. Cusp of uncertain homologies among heteromyids, apparently closely connected with the protoconid in its origin.

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A NEW RODENT FROM THE PLIOCENE OF KANSAS

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ABSTRACT

Kansasimys dubius Wood, n. gen. and sp., is compared with *Sciuravus*, but differs enough to be excluded from the Sciuravidae.

During a recent visit, as Cutting Traveling Fellow in Columbia University, to the University of California, I had opportunity through the courtesy of Mr. C. J. Hesse to examine the jaw of a very interesting rodent. The specimen came from a locality near Edson, Kansas, and is the property of the University of Kansas. Mr. Hesse and Prof. H. H. Lane, of the University of Kansas, have very kindly allowed me to describe the specimen.

Genus KANSASIMYS Wood, n. gen.

Genotype: *K. dubius* Wood.

The generic characters are those of the genotype.

KANSASIMYS DUBIUS Wood, n. sp.

Text-figure 1

Holotype: Univ. Kansas 3582, lower jaw with P_4—M_2 left, and alveolus of M_3.

Horizon and locality: Middle Pliocene, near base of Ogallala formation; Edson quarry, sec. 25, T. 10 S., R. 38 W., near Edson, Sherman County, Kansas (see Hibbard, 1934); coll. H. T. Martin and party, July 20, 1926.

Diagnosis: A rodent with four subequal lower cheek teeth; pattern with superficial resemblances to that of *Sciuravus*, cricetids and *Ischyromys*, but with well developed mesoconid; anterior cingulum continuous across entire front of molars; posterior arm of protoconid aborted.

Masseteric fossa of unusual shape, ending anteriorly in a sharp angle, below middle of P_4; long lower margin of fossa almost exactly parallel to alveolar border; upper margin rises at about 30°, continues evenly, but at an increasing slope, up anterior edge of ascending ramus. Distinct knob for base of incisor, whose thin upper surface is broken through in this specimen. Mental foramen on level with lower surface of masseteric fossa, well anterior to premolar; anterior root of this tooth, exposed by the breaking of the jaw, extremely long, about $2\frac{1}{2}$ times as long as crown is high. No pit between M_3 and coronoid process. Jaw short, massive, as in the cylindrodonts.

Tooth measurements as follows: P_4—M_3, alveolar length, 9.30 mm. P_4, antero-posterior, 1.93; anterior width, 1.60; posterior width, 2.06 mm. M_1, antero-posterior, 2.25; anterior width, 2.13; posterior width, 2.17 mm. M_2, antero-posterior, 2.30; anterior width, 2.13; posterior width, 2.06 mm.

Discussion.—The resemblance of this form to the Eocene *Sciuravus* is so great that, at first sight, one is tempted to place it among the Sciuravidae. More careful study of the teeth, though revealing important distinctions, confirms many of the resemblances. The mesoconid (see pp. 388–391 for an explanation of the cusp terminology used) is an evenly rounded cusp in the present form, as in *Sciuravus* (fig. 2). In size, the two genera are fairly similar. In *Kansasimys*, the primary cusps are slightly plumper and more distinct than in *Sciuravus*, the

teeth are slightly more lophodont and hypsodont, and the buccal halves of the anterior cingula of the molars are distinctly separated from the protoconids (fig. 1). In *Sciuravus*, the posterior arm of the protoconid is long and extends in a ridge toward the metaconid, and protolophulid 2 is as strongly developed as protolophulid 1. It is as if *Sciuravus* stands near the point where two lines of evolution diverged, one leading to forms with protolophulid 1 (a crest via the anterior ends of the protoconid and metaconid, as in *Kansasimys*); the other leading to those forms with protolophulid II (the crest connecting the posterior arms of the two cups). The great significance of the divergent development of these crests has recently been pointed out among the cylindrodonts by Burke (2).

In contradistinction to *Sciuravus*, there is in the molars of *Kansasimys* no trace of the posterior arm of the protoconid other than the crest uniting the protoconid with the mesoconid, which probably represents the ectolophid rather than the posterior arm of the protoconid. This is an important distinction, and though the possibility of special relationship to *Sciuravus* cannot be ruled out it must at the very least be extremely distant. Another feature separating the two genera is the essential conformity in *Kansasimys* of height between the talonid and the trigonid, a feature, however, merely correlated with the more antero-posterior rather than vertical movement of the jaws, characteristic of late Tertiary and Recent rodents. It is clear that the absence of the posterior arm of the protoconid separates *Kansasimys* from the Sciuravidae, and that this same character, among others, separates it from the Adjidaumidae, Dipodidae, and Cricetidae, none of which it resembles as much as it does *Sciuravus*.

Another group of rodents that might be compared with *Kansasimys* are the forms that show a similar reduction of the posterior arm of the protoconid. Here may be listed the Paramyidae, *Mysops*, *Prosciurus*, *Eutypomys*, *Plesiospermophilus*, the Ischyromyidae, the Cylindrodontidae, and the Sciuridae. In most of these, however, there is no enteroconid. In those in which it is present, such as the Paramyidae, *Prosciurus*, *Plesiospermophilus*, and the Sciuridae, it is small and, together with the ectolophid, is in an extremely buccal position, so that a large central basin is present, thus differing

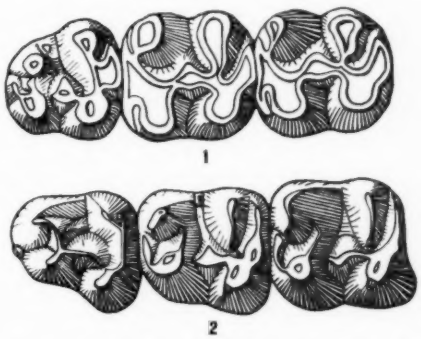

FIG. 1—*Kansasimys dubius* Wood, n. gen. and sp., holotype, $P_4^-M_3^-$ left, ×8; Univ. Kansas 3582.
2—*Sciuravus undans* Marsh, holotype, $P_4^-M_3^-$ right, reversed, ×8; Yale Peabody Museum 13349.

sharply from *Kansasimys*. Of these forms, *Prosciurus* stands closest to *Kansasimys*, apparently being a modified sciuravid with the posterior arm of the protoconid reduced. The pattern of *Eutypomys* has certain features reminiscent of *Kansasimys*, and in the entire uncertainty as to relationships, it is possible that a connection may exist. *Eutypomys*, however, is certainly much too hypsodont to have close affinities with *Kansasimys*. On the whole, the members of this group that have the greatest similarity to *Kansasimys* are *Ardynomys*, of the Oligocene of Mongolia, and *Sespemys*, of the upper Oligocene of California, both of which also resemble the Cylindrodontidae. In the presence of protolophulid I, the similarity of *Kansasimys* to *Ardynomys* and *Sespemys* is quite notable, the three

genera being almost identical in this respect. *Kansasimys* seems slightly more specialized in that there is a distinct valley between the anterior cingulum and the metaconid, formed, apparently, by a retreat of that cusp from the anterior edge of the tooth. According to this interpretation, the anterior cingulum of rodent molars would be in part a secondary development, a thesis fitting with the belief that the teeth of *Paramys* indicate the prototype from which the later rodent types have been evolved. The ectolophid is much more nearly in the center of the tooth in *Kansasimys* than in any other genus compared, probably a specialized character; and correlated with this, it is more nearly antero-posterior, instead of diagonal as in *Ischyromys* (5*a*). Another character separating the molars of this form from those of the other genera is the continuity of the anterior cingulum, which is separated not only from the metaconid but also from the protoconid, a distinctly cricetine character.

In the premolar, the similarity of *Kansasimys* to *Ischyromys* is marked, for the anterior half of the tooth is almost the same in the two genera. A mesoconid is present in this tooth as well as in the molars, thus separating *Kansasimys* from the ischyromyids, though the ectolophid is much nearer the buccal side of the tooth than in the molars. The presence of a large hypoconulid serves further to distinguish this genus from *Ischyromys*. The almost equally large hypoconulid in both *Sespemys* and *Ardynomys* is more like the hypoconulids of the molars of *Kansasimys* (fig. 1), that is, relatively narrow and elongate, instead of sharply quadrilateral with little trace of cingular origin.

In conclusion, this form from the Pliocene of Kansas is quite distinct from all forms with which it has been compared. It seems most like the cylindrodonts and ischyromyids on the one hand, and *Sciuravus* on the other. It is inadvisable, however, at the present time to assign this genus to any family. The only possible course would be to erect a new family, but I would prefer not to do this on a single mandible. *Kansasimys* combines within itself characters previously recorded only from one or the other of two groups of rodent families which seem to have been specializing in quite different directions. The greatest similarity is found in the Middle Eocene *Sciuravus*, a relatively primitive form, which may actually be related to *Kansasimys*. It is to be hoped that more complete specimens will soon be found to help solve the riddle.

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THE NEMESTRINIDAE OF THE MIOCENE OF FLORISSANT, COLORADO, AND THEIR RELATIONS TO THE RECENT FAUNA

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ABSTRACT

The characteristics and classification of the living representatives of the insect family Nemestrinidae are briefly described, and the five fossil species from Florissant, Colorado, are treated in detail. The fossil forms are so close to living forms that it may be said that no evolution has taken place since the Miocene.

In the course of his studies of the Nemestrinidae carried on for the past fifteen years, the senior author has often felt the desire to examine critically the members of the family which have been described from the Miocene shales of Florissant, Colorado. The junior author has recently been able to get together the types of all these species, and the present study is the result of a careful comparison of these fossils with representatives of nearly all the known living genera, and an attempt to trace the relationships of the extinct forms with those of the present-day fauna.

Acknowledgments.—We wish to thank the authorities of the American Museum of Natural History, the Peabody Museum at Yale University, and the University of Colorado Museum, for the privilege of examining valuable type material.

THE RECENT NEMESTRINIDAE

The discussion of the fossil Nemestrinidae will be much simplified, if we first consider the most important characters and the classification of the living representatives of the family. They are medium-sized to fairly large flies, without macrochaetae (eremochaetous). The head is broad and short, more or less hemispherical, and mostly taken up by the eyes, which may be bare or pubescent, and either in contact with each other (holoptic) or more or less separated (dichoptic) on the middle line. The frons and vertex are flat or very slightly convex, never concave. Ocelli are present or absent. The mouth-parts, or proboscis, may be short and fleshy, or elongate and stylet-like, or rudimentary, or aborted. The palpi may be one-, two-, or three-segmented, sometimes much reduced or even aborted. The antennae are small, short, three-segmented (brachycerous), with a terminal arista-like, three-segmented, bare style. The thorax and abdomen are broad and thick-set. The ovipositor is long, either composed of several retractile segments with short terminal valvulae, or of very long and sabre-shaped valvulae. The legs are long and slender. The tibiae lack spurs, and the empodia are pulvilliform, there being three subequal pads or pulvilli between the claws. The wings are large; the alar squamae very small, often indistinct; the

thoracic squamae vestigial or absent; as a rule the base of the wing is connected with the sides of the thorax by means of a narrow, fringed membrane. The venation is unique and best studied by referring to fig. 1; the most conspicuous features are: 1. The "diagonal vein," which runs obliquely across the wing from the anterior to the posterior third; this is not actually a single vein, but a structure which results from the tying together of the longitudinal veins at various points, either through shortening of the cross-veins or through coalescence, or by a combination of both processes. Many of the other features of the venation, such as the lengthening along the horizontal axis of the wing of the discal, posterior, and anal cells, are evidently conditioned by the diagonal vein. The exact equivalent of the diagonal vein is not found elsewhere among the Diptera, but in some of the Apioceridae and Mydaidae there is an approach to it which illustrates the manner in which the nemestrinid venation may have originated. 2. The costa generally encloses the wing completely. In the few cases where it apparently terminates at or near the apex of the wing, vestiges can be traced along the hind margin. 3. The auxiliary and first and second longitudinal veins are long and parallel to the costa, in which they end separately. This feature differentiates the Nemestrinidae from the Mydaidae and Apioceridae, where the second longitudinal vein joins the first and does not reach the costa. 4. With few exceptions, the discal, submarginal and posterior cells are greatly lengthened and all arranged parallel to one another in the horizontal axis of the wing. 5. With the exception of the humeral cross-vein, the usual cross-veins tend to disappear and are often lacking, a feature directly correlated with the development of the "diagonal vein." 6. In some genera there is a tendency to complicate the venation by means of supernumerary cross-veins. In certain cases these cross-veins are purely abnormal, while in others they are regular features of some species or groups of species. It is interesting to note that these supernumerary cross-veins have arisen independently in at least two lines of descent. In the subfamily Hirmoneurinae the tendency towards the development of these cross-veins is ex-

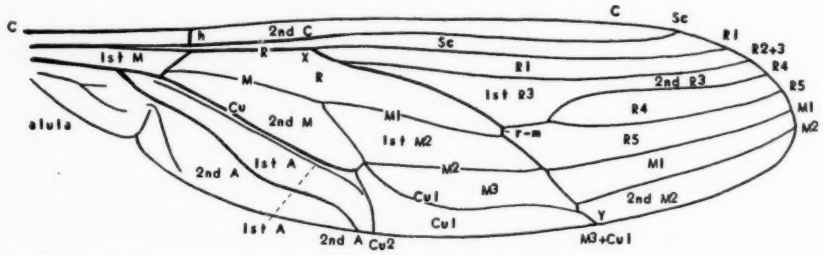

FIG. 1—Wing of *Hirmoneura bradleyi* J. Bequaert, with the Comstock notation (See Comstock, 1918, *The wings of insects*, p. 347, fig. 358, showing the wing of *Trichopsidea* (*Parasymmictus*) *clausa* Osten Sacken). The corresponding nomenclature of Williston, used in this paper, is as follows: Veins: *C*, costa; *SC*, subcosta or auxiliary vein; *R*, R_1, first longitudinal; R_{2+3}, second longitudinal; R_4 and R_5, upper and lower branches of third longitudinal; *M*, fourth longitudinal, and its upper (M_1) and lower (M_2) branches; *Cu*, fifth longitudinal and its upper (Cu_1) and lower (Cu_2) branches; 1st *A* (this is not visible in any of the fossil wings examined by us); 2nd *A*, sixth longitudinal; *h*, humeral cross-vein; *r-m*, anterior cross-vein; *X-Y*, "diagonal vein."—Cells: 2nd *C*, costal; *SC*, subcostal; R_1, marginal; 1st R_3 and 2nd R_3, first and second submarginals (united in *H. bradleyi*); R_4 third submarginal; R_5, first posterior; M_1 second posterior; 2nd M_2, third posterior; M_3 fourth posterior; Cu_1, fifth posterior; 1st M_2, discal; *R*, first basal; 2nd *M*, second basal; 1st *A*, anal; 2nd *A*, axillary.

hibited by the Recent species of the subgenus *Austrohirmoneura* and the fossil *Hirmoneurites*. In the subfamily Nemestrininae it is found in certain species of *Nemestrinus* and in all species of *Moegistorhynchus*. In the subgenus *Heminemestrinus* the supernumerary cross-veins are few in number, the venation being not unlike that of certain species of *Austrohirmoneura*. In the subgenera *Nemestrinus*, proper, and *Nemestrellus*, as well as in *Moegistorhynchus*, their number increases, however, to such an extent that the apical third to half of the wing becomes reticulated. A similar tendency to produce a net-work of cross-veins is not known to us in any other family of Diptera. In the Nemestrinidae it is probably also a sequel to the formation of the "diagonal vein," which necessitated a further strengthening of the membrane in the apical portion of the wing (1). It should be noted that in minor details the venation is usually quite variable within specific limits, particularly in the number and position of the supernumerary cross-veins. This point should be kept in mind while studying the fossil species, which are mostly known from single, imperfectly preserved specimens.

The Nemestrinidae occupy a rather isolated position in the living fauna, pointing to the great antiquity of the family, a fact which is supported by paleontology as well as by the present-day disconnected geographical distribution. Perhaps their nearest relatives are the Cyrtidae, with which they agree in many respects, notably in the lack of macrochaetae and the possession of pulvilliform empodia, though the Cyrtidae are readily separated by the large squamae. As pointed out by Verrall, the venation of certain Cyrtidae offers some points in common with the Nemestrinidae, though there is a question whether specialization of the wing has not progressed along different lines in both families. Moreover, the similarity in the venation is perhaps of little phylogenetic value, since a greater approach to that of the Nemestrinidae is found in the wing of some Mydaidae and Apioceridae, and even occasionally in Asilidae. Yet there is no reason to regard these latter families as in any way more closely related to the Nemestrinidae than the other Diptera Orthorhapha Brachycera. In all three families, the empodia are bristle-like or wanting. In the Mydaidae and Asilidae the vertex and frons are concave between the eyes, whereas in the Asilidae and Apioceridae macrochaetae are present. The resemblance between some of the Bombyliidae and certain Nemestrinidae is purely superficial, the former having the empodia or even the pulvilli bristle-like or rudimentary, and showing no tendency toward the production of a "diagonal vein" in the wing. The lack of spurs on the tibiae and the nature of the venation separate the Nemestrinidae from the Leptidae (Rhagionidae), which have spurs on at least the middle tibiae and show no tendency to form a "diagonal vein."

The foregoing discussion of the family characters may be useful in recognizing fossil members of the family. Those that have been described as such from Florissant quite clearly belong there and moreover are not generically distinct from the Recent forms, although there might be some difference of opinion as to the precise genus to which each species should be referred. After studying nearly all known genera and the great majority of the living species, the senior author has adopted a classification of the Nemestrinidae into three subfamilies, characterized as shown in the subjoined key (2).

1. Proboscis much reduced, more or less vestigial or aborted. Palpi either well developed, slender and hidden in deep grooves on both sides of the face, or vestigial. Ovipositor sabre-shaped. Alula usually vestigial or absent, very rarely well developed (*Nycterimyia* and *Ceyloniola*)..... *Trichopsideinae*

   Proboscis well developed, short or long. Palpi well developed. Alula always present, usually broad, rarely much narrowed.....2

2. Proboscis very short, always much shorter than the height of the head, the labium ending in broad, soft labella. Face never prominent, deeply excavated below. Palpi usually distinctly three-segmented, resting in deep grooves on both sides of the face, close to the inner orbits. Ovipositor telescope-shaped, the terminal valvulae short ..... *Hirmoneurinae*

Proboscis long and slender, at least as long as the height of the head; the labium usually ending in narrow labella. Face convex and more or less prominent, sometimes snout-like. Palpi usually two-segmented (the third segment at most rudimentary), not placed in grooves along the sides of the face. Ovipositor either telescope-shaped or sabre-shaped..... *Nemestrininae*

The present-day distribution of the family is highly suggestive, consisting in the main of five disconnected areas. About ninety per cent of the species are found in (1) the United States and Mexico; (2) Chile and Argentina; (3) Africa south of the Zambesi; (4) the Mediterranean subregion, from Spain and Morocco to Turkestan; (5) New Guinea, Australia and Tasmania. No Hirmoneurinae have as yet been described from the Australian and South African areas, nor any Trichopsideinae from the Chilean area; the other two areas have representatives of all three subfamilies. In the remaining geographical regions the family has only scattered representatives. The Oriental region possesses thirteen Hirmoneurinae and seven Trichopsideinae. Tropical Africa has only three species, all of the subfamily Trichopsideinae. In tropical America the family is almost lacking; only some of the Nearctic species extend southward to Guatemala, while Ecuador, Peru, and southern Brazil possess a few species of *Hirmoneura*, allied to the Chilean fauna.

The known living genera are listed below:

1. Hirmoneurinae: One genus, *Hirmoneura* Meigen (including the subgenera *Hyrmophlaeba* Rondani, *Austrohirmoneura* J. Bequaert, *Indohirmoneura* J. Bequaert, *Hirmoneurilla* J. Bequaert, *Hirmoneuropsis* J. Bequaert, and *Neohirmoneura* J. Bequaert). The majority of the 35 to 40 species are found in Chile, Argentina, Peru and Ecuador; a few in the Mediterranean subregion, the Oriental region, and the Nearctic region.

2. Nemestrininae: 8 genera—*Nemestrinus* Latreille (including the subgenera *Rhynchocephalus* Fischer, *Symmictoides* J. Bequaert, *Heminemestrinus* J. Bequaert, and *Nemestrellus* Sack; 45 to 50 species in the Mediterranean subregion); *Fallenia* Meigen (2 species in the Mediterranean subregion); *Neorhynchocephalus* Lichtwardt (7 species in the Mediterranean subregion, Argentina and the Nearctic region); *Trichophthalma* Westwood (including the subgenera *Eurygastromyia* Lichtwardt, *Lichtwardtiomyia* J. Bequaert, and *Austrogastromyia* J. Bequaert; 45 to 50 species, in Australia, Tasmania and Chile); *Stenopteromyia* Lichtwardt (1 species in the Mediterranean subregion); *Prosoeca* Schiner (30 species in South Africa); *Moegistorhynchus* Macquart (4 species in South Africa); *Stenobasipteron* Lichtwardt (5 species in South Africa).

3. Trichopsideinae: 6 genera—*Atriadops* Wandolleck (2 species, one of tropical Africa, the other of the Malayan and Australian regions); *Cyclopsidea* Mackerras (1 species in Australia); *Nycterimorpha* Lichtwardt (2 species in the Oriental and Australian regions); *Nycterimyia* Lichtwardt (4 species in the Indo-Australian and Ethiopian regions); *Ceyloniola* Strand (1 species in Ceylon); *Trichopsidea* Westwood (including the subgenera *Dicrotrypana* Bigot, *Symmictus* Loew and *Parasymmictus* Bigot; 4 species in the Mediterranean subregion, the Nearctic, South African, and the Papuan-Australian regions).

THE FOSSIL NEMESTRINIDAE

In addition to the species from the Miocene of Florissant, studied more particularly in this paper, two fossils from other strata have also been referred to the Nemestrinidae. In his enumeration of the fossil insects found in the "Tertiary calcareous marls" of Aix, in southern France (now generally referred to the

Oligocene), M. de Serres (3) includes "*Nemestrina* Latreille. Une espèce de la taille de la *Nemestrina reticulata* de Latreille." This would seem to point to a species with reticulated wings. *Prohirmoneura jurassica* Handlirsch (4) was described from the Lithographic limestone of Blumenberg near Eichstatt, Bavaria (referred to the Malm or upper Jurassic). This fossil was poorly preserved and since we have not been able to study it, we can only accept Handlirsch's identification. If the drawing and description are to be trusted, the fossil would seem to have been a true *Hirmoneura*, apparently similar to some of the living members of the subgenus *Hirmoneuropsis*. It is highly desirable that a new search be made for Diptera in the Lithographic limestone of Bavaria. Even at present, only one other member of the Diptera Orthorhapha Brachycera is known from the Mesozoic (*Protobrachyceron liasinum* Handlirsch).

Five species of Nemestrinidae have been described from Florissant and our studies have convinced us that there is every reason to regard them as distinct. They seem, however, to be referable to at least three of the present-day genera. Their main diagnostic characters are shown in the subjoined key.

1. Two complete submarginal cells; first submarginal cell connected by a cross-vein with the discal cell; base of fourth posterior cell removed far from anal cell; sixth longitudinal vein nearly straight; proboscis very long; face very protuberant, snout-like. Eyes bare. Alula present, but very narrow ..... *Prosoeca* (*Palembolus*) *florigera*

   Three complete submarginal cells 2

2. Second posterior cell divided by a supernumerary cross-vein; first submarginal cell connected by a cross-vein with discal cell; base of fourth posterior cell removed far from anal cell; (alula and sixth longitudinal vein unknown); proboscis presumably short; face not protuberant. Eyes presumably bare ..... *Hirmoneura* (*Hirmoneurites*) *willistoni*

   Second posterior cell not divided by a cross-vein; first submarginal cell in contact with discal cell 3

3. Fourth posterior cell very wide at base, broadly touching anal cell; second submarginal cell broadly truncate at base; alula narrowed; sixth longitudinal vein wavy ..... *Neorhynchocephalus? melanderi*

   Fourth posterior cell not broadly connected at base with anal cell 4

4. Second submarginal and fourth posterior cells both very wide at base; sixth longitudinal vein nearly straight; alula narrowed(?) ..... *Neorhynchocephalus vulcanicus*

   Second submarginal and fourth posterior cells both very narrow (contracted) at base; sixth longitudinal vein wavy; alula broad ..... *Neorhynchocephalus occultator*

HIRMONEURA (HIRMONEURITES) WILLISTONI (Cockerell)

Figures 2, 7 (2)

Hirmoneurites willistoni COCKERELL, *1910*, Am. Mus. Nat. Hist., Bull., vol. 28, pp. 283, 286, fig. 3.

Hirmoneura willistoni J. BEQUAERT, *1932*, Zoolog. Anz., vol. 100, p. 15.

The type (no. 10244) at the American Museum of Natural History was examined by us. It is well preserved, although owing to the fact that the wings are not spread out, much of their proximal portion is obscure. Cockerell's description is accurate. The insect is robust, thickset, and quite different in appearance from the other Nemestrinidae known from the Florissant shales. The head is broad, evenly rounded-off anteriorly, without swollen face or trace of proboscis, so that it may be assumed that the proboscis was short and soft as in the living Hirmoneurinae. Antennae and palpi are lacking. The eyes are quite distinct and show no trace of pubescence; they are broadly separated throughout by the vertex and frons. The thorax shows no peculiarities. The four basal

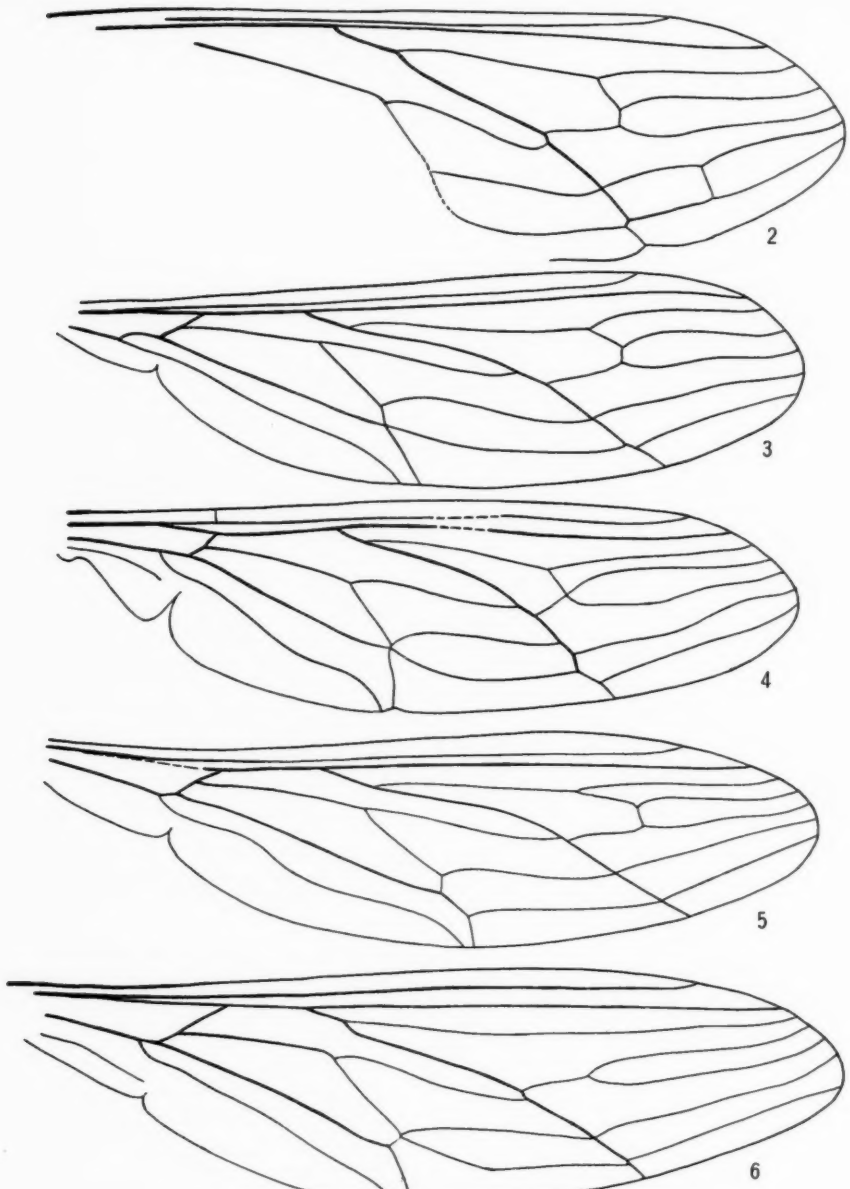

FIG. 2—*Hirmoneura* (*Hirmoneurites*) *willistoni* (Cockerell). Right wing of type.
3—*Neorhynchocephalus vulcanicus* (Cockerell). Right wing of type.
4—*Neorhynchocephalus occultator* (Cockerell). Right wing of type.
5—*Neorhynchocephalus? melanderi* (Cockerell). Right wing of type.
6—*Prosoeca* (*Palembolus*) *florigera* (Scudder). Right wing of type.

segments of the abdomen are well marked, very gradually decreasing in width from the first to the fourth; behind this comes an ovipositor of apparently three narrow segments ending in a sharp point, evidently formed by the two terminal valvulae; the ovipositor is therefore telescope-shaped, as in all living Hirmoneurinae and some Nemestrininae. The legs are only partly preserved; the left hind tarsi end in two claws and three narrow pads (two pulvilli and a pulvilliform empodium, as in all Recent Nemestrinidae). The venation is distinct only in the apical half of the wing; the alula, the apex of the second basal and anal cells, and the sixth longitudinal vein cannot be traced. The most important features are: (*a*) three complete submarginal cells, the third being very broadly truncate at the base; (*b*) a well-marked cross-vein (part of the diagonal vein) connects the first submarginal cell with the discal cell, these two cells not touching each other; (*c*) the diagonal vein reaches the hind margin of the wing, its terminal abscissa strongly deflected from the general course of the vein, the third and fourth posterior cells in contact for a short distance; (*d*) a rather pronounced notch of the hind margin of the wing at the tip of the diagonal vein; (*e*) a distinct supernumerary cross-vein divides the second posterior cell a little beyond the basal third, this cross-vein being present in the same position in both wings; (*f*) the first and second submartinal and first and second posterior cells open broadly at the margin of the wing; (*g*) the costa encircles the wing as far as it can be followed beyond the apex.

The telescope-shaped ovipositor and short proboscis refer this fossil to the subfamily Hirmoneurinae, with the one genus, *Hirmoneura*. Among the living species only those of the subgenera *Hyrmophlaeba* and *Austrohirmoneura* have three complete submarginal cells. Accessory cross-veins are absent in *Hyrmophlaeba*, which, moreover, has pubescent eyes. On the other hand, in *Austrohirmoneura*, which comprises three species (*bellula* Philippi, *articulata* Philippi, *maculipennis* Macquart) in Chile, the first or second posterior cells, or both, are normally subdivided by an accessory cross-vein; but in all these species the eyes are densely pubescent. *Hirmoneurites* may therefore be regarded as forming a subgenus of *Hirmoneura*, closely related to *Austrohirmoneura*, from which it differs mainly in the bare eyes. Most of the other peculiarities of the venation of *willistoni* mentioned above are also present in the living species of *Austrohirmoneura*. In these, moreover, the number of accessory cross-veins is rather variable within specific limits: most specimens have a cross-vein in both the first and second posterior cells; occasionally that of the first is lacking, more rarely that of the second. In some specimens of *H. maculipennis* there is also an accessory cross-vein in the third submarginal cell, so that a second, incomplete "diagonal vein" is formed in the apical third of the wing. Sometimes also the third submarginal or first or second posterior cells have more than one accessory vein.

In living *Hirmoneura*, bare eyes are found in the subgenera *Indohirmoneura*, *Hirmoneuropsis* and *Neohirmoneura;* but all these differ from *Hirmoneurites* in having only two complete submarginal cells and no cross-veins in the second posterior cell (except as abnormalities).

NEORHYNCHOCEPHALUS VULCANICUS (Cockerell)

Figures 3, 7 (4)

Hirmoneura vulcanica COCKERELL, *1908*, Am. Jour. Sci., vol. 25, p. 311; *1908*, Am. Ent. Soc., Trans., vol. 34, pp. 251, 253; *1910*, Am. Mus. Nat. Hist., Bull., vol. 28, p. 286.

We have studied the obverse of the type (no. 14173) in the Peabody Museum, Yale University; and the junior author has also examined the reverse specimen in the University of Colorado Museum. The fossil is moderately well preserved. It shows the head (in part),

thorax, abdomen and both wings; also parts of the legs. The head has little detail: the left eye is preserved, showing some of the facets, and seemingly bare; the wide frons is distinctly hairy; no trace of antennae; the impression of the face is broken away from the slab; however, a short distance from and directly in front of the head one can see faint impressions of four rods, spread apart and seemingly converging toward the head, but without reaching it; these are to all appearances the four parts of an elongate proboscis, thus referring the fossil to the subfamily Nemestrininae. The thorax shows nothing peculiar. The abdomen seems to consist of six sclerites, which are little spread apart and decrease gradually in width from base to apex; the abdomen ends in a sabre-shaped ovipositor, which is sharply bent before the end and curled up at the tip (this feature also removes the fossil from the subfamily Hirmoneurinae). Thorax and abdomen show no trace of pubescence. The wings seem to have a rather narrow alula at the base, but this is difficult to make out and remains somewhat uncertain. The main features of the venation are: (*a*) the presence of a cross-vein between the second longitudinal and upper branch of third longitudinal veins, there being three complete submarginal cells, the third very broadly truncate at base; (*b*) the fourth longitudinal reaches the diagonal vein some distance before the branching off of the third longitudinal, so that the first submarginal cell touches the discal cell; (*c*) the diagonal vein extends beyond the second and fourth posterior cells to the hind margin of the wing; (*d*) the fourth posterior cell is broad at the base, but does not touch the anal cell; (*e*) the apical portion of the wing has no accessory cross-veins; (*f*) the submarginal and posterior cells all open broadly on the apical margin of the wing; (*g*) the sixth longitudinal vein (*2dA*) is nearly straight; (*h*) the costa encircles the wing completely.

The presence of a long proboscis and of a sabre-shaped ovipositor, overlooked by Cockerell, removes *vulcanica* from the Hirmoneurinae, and the long proboscis places it in the Nemestrininae. On account of the three submarginal cells, the second and third open at the margin, the bare eyes, and the sabre-shaped ovipositor, it can be referred only to *Neorhynchocephalus* among the Recent genera. The only other genus of Nemestrininae with a sabre-shaped ovipositor, *Fallenia*, has an unusual venation, with the third submarginal cell closed and very short, connected with the costa by means of a long stalk which in turn receives the upper branch of the fourth longitudinal vein much before the margin.

NEORHYNCHOCEPHALUS OCCULTATOR (Cockerell)

Figures 4, 7 (1)

Hirmoneura occultator COCKERELL, *1908*, Am, Ent. Soc., Trans., vol. 34, p. 254; *1910*. Am. Mus. Nat. Hist., Bull., vol. 28, p. 286.

The type (obverse), at the University of Colorado Museum, was examined by us. It is in fair condition. Cockerell's description is on the whole accurate. Thorax, abdomen and right wing are shown almost entirely; parts of the legs on the right side are also visible. Of the head, only part of the right side is preserved, showing the large, facetted, apparently bare eye; but the outlines of vertex and frons cannot be traced; no trace is seen of mouth-parts and antenna. Only a portion of the hind margin of the left wing is present. The long, curved, sabre-shaped ovipositor is very distinct, which feature at once excludes this fossil from the Hirmoneurinae, all the living members of which have a telescope-shaped ovipositor. The alula is very broad. The venation shows the following main features: (*a*) three complete submarginal cells, the third very narrow, pointed at the base; (*b*) the fourth longitudinal reaches the diagonal vein some distance before the branching

off of the third longitudinal, so that the first submarginal cell touches the discal cell; (*c*) the diagonal vein extends beyond the second and fourth posterior cells to the hind margin of the wing; (*d*) the fourth posterior cell is narrow and pointed at the base, and does not come in contact with the anal cell; (*e*) the apical portion of the wing has no accessory cross-veins; (*f*) the submarginal and posterior cells all open broadly on the apical margin of the wing; (*g*) the sixth longitudinal vein is very wavy; (*h*) the costa encircles the wing completely.

A sabre-shaped ovipositor is found in some genera of both the Nemestrininae and Trichopsideinae, and, as the mouth-parts of *occultator* are unknown, there may be a question as to where to place it. However, nearly all living Trichopsideinae have the alula of the wing vestigial; while even in the two exceptional genera, *Nycterimyia* and *Ceyloniola*, it is much narrower than usual. On the other hand, a broad alula is the rule, with few exceptions, in the Nemestrininae. Moreover, the venation of *occultator* duplicates almost exactly that of certain specimens we have seen of the living North American *Neorhynchocephalus volaticus* (Williston). There can be little doubt, in our opinion, that *occultator* is a *Neorhynchocephalus*, since this genus has a sabre-shaped ovipositor.

N. occultator is indeed so close to *N. volaticus*, that we are unable to point out specific differences. The living species varies considerably in size, and we have seen specimens fully as large as the fossil. Nevertheless, it would be hazardous to claim that *occultator* and *volaticus* are the same species, which survived without apparent change since Miocene times. In the living *Neorhynchocephalus* some of most reliable specific differences are exhibited by the head, particularly the relative width of frons and vertex, which are unknown in *occultator*.

NEORHYNCHOCEPHALUS? MELANDERI (Cockerell)

Figures 5, 7(3)

Hirmoneura melanderi COCKERELL, *1908*, Am. Jour. Sci., vol. 25, p. 311; *1908*, Am. Ent. Soc., Trans., vol. 34, pp. 251 and 253, Pl. 16, fig. 4; *1910*, Am. Mus. Nat. Hist., Bull., vol. 28, p. 286.

We have studied the type (obverse, no. 14172) in the Peabody Museum, Yale University; the reverse, in the University of Colorado Museum, has also been examined by the junior author. There are two other specimens of this species in the Scudder Collection at the Museum of Comparative Zoology, Harvard University; one of these (no. 3644) is a very well preserved male. They show no noteworthy difference from the type. A fourth specimen of *melanderi*, recorded by Cockerell in 1908,

> shows the abdomen and wings, but lacks the head and nearly all of the thorax. It agrees with the type, except that the abdomen is very long and tapering, the distance from the base of the wings to the tip of the abdomen being about 15 mm. In its general shape, the abdomen is suggestive of some species of *Nemestrina*. The specimen is probably a female.

We regret that we were unable to examine this specimen, the description of which suggests the presence of a telescope-shaped ovipositor.

The type is only fair. Cockerell's description is accurate. Head, thorax, abdomen and both wings are present, as well as parts of some of the legs. The head shows little detail; on one side the eye facets are well-marked, the eyes being seemingly bare; the shape of frons and vertex cannot be seen; in front of the eyes there is a pronounced convex face bearing some long hairs; no trace of antennae and mouth-parts is discernible, but the presence of a convex face would seem to indicate that the proboscis was elongate and was pressed down beneath the body in this specimen. On the thorax, the scutellum is well-defined, ending in the swollen rim found in all Nemes-

trinidae. The abdomen shows six sclerites, separated by intervals which gradually increase in width from base to apex; the basal four sclerites are of about equal width while the fifth and sixth are much narrower; the second to fifth sclerites show a distinct depressed basal area, occupying about one-fourth of the sclerite on the third and fourth, and one-third on the second and fifth. A similar division of the tergites is seen in Recent Nemestrinidae, the basal area being more or less retracted in life beneath the apical margin of the preceding tergite. The sixth sclerite is broadly rounded off apically and may or may not represent the male terminalia; possibly it was followed by other, missing sclerites. No hairs are visible on thorax and abdomen. The right wing is much better preserved than the left wing; it shows at the base a distinct, but somewhat narrowed alula, not visible in the left wing. The most striking features of the venation are: (*a*) the presence of a cross-vein between the second longitudinal and upper branch of third longitudinal veins, there being three complete submarginal cells, the third broadly truncate at the base; (*b*) the fourth longitudinal reaches the diagonal vein a short distance before the branching off of the third longitudinal, so that the first submarginal cell touches the discal cell; (*c*) the diagonal vein extends beyond the second and fourth posterior cells to the hind margin of the wing; (*d*) the longitudinal veins forming the upper and lower sides of the second and fourth posterior cells are continuous across the diagonal vein; (*e*) the base of the fourth posterior cell is very broad, so that this cell touches very broadly both the second basal and the anal cell; (*f*) the apical portion of the wing has no accessory cross-veins; (*g*) the submarginal and posterior cells all open broadly on the apical margin of the wing; (*h*) the sixth longitudinal vein is very wavy; (*i*) the costa encircles the wing completely.

The convex face of *melanderi* would seem to point to the existence of a long proboscis and refer *melanderi* to the subfamily Nemestrininae. None of the living Hirmoneurinae and Trichopsideinae show the slightest indication of a facial convexity. Assuming this conclusion to be correct, the presence of three submarginal cells, the second and third broadly open at the margin of the wing, excludes the living genera *Stenopteromyia*, *Stenobasipteron*, *Trichophthalma* and *Prosoeca*. The open third submarginal cell eliminates *Fallenia*, and the non-reticulate wing, *Moegistorhynchus*. The three submarginal cells differentiate *melanderi* from *Palembolus florigerus*. Our fossil might then be either *Neorhynchocephalus* (none of which have reticulate wings) or *Nemestrinus* (some species of which, forming the subgenera *Rhynchocephalus* and *Symmictoides*, have non-reticulate wings). These two genera differ essentially in the structure of the ovipositor, sabre-shaped in *Neorhynchocephalus*, telescope-shaped in *Nemestrinus*. Unfortunately the ovipositor of *melanderi* is not definitely known. However, the unusually broad base of the fourth posterior cell seems to favor *Neorhynchocephalus*. This feature is not found in any

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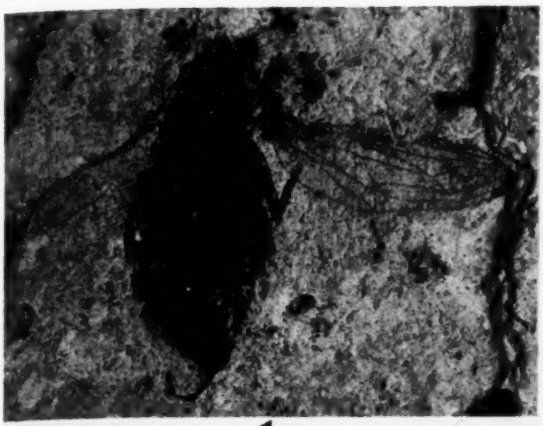
FIG. 7 (1–5)—Nemestrinidae from the Miocene of Florissant, Colorado.
(1)—*Neorhynchocephalus occultator* (Cockerell), type specimen, Univ. Colorado Mus. (p. 402)
(2)—*Hirmoneura* (*Hirmoneurites*) *willistoni* (Cockerell), type specimen, Am. Mus. Nat. Hist. 10244. (p. 399)
(3)—*Neorhynchocephalus*? *melanderi* (Cockerell), type specimen, Peabody Mus. Yale Univ. 14172. (p. 403)
(4)—*Neorhynchocephalus vulcanicus* (Cockerell), type specimen, Peabody Mus. Yale Univ. 14173. (p. 401)
(5)—*Prosoeca* (*Palembolus*) *florigera* (Scudder), type specimen, Mus. Comp. Zool. 3642 (p. 406)



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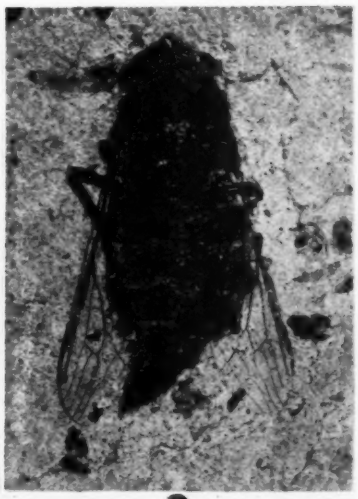

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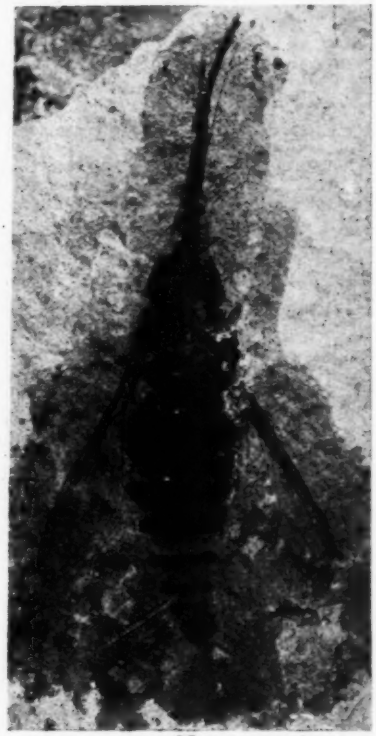

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living species of *Nemestrinus, Stenopteromyia, Fallenia, Prosoeca, Trichophthalma* and *Stenobasipteron;* and it is also absent in *Palembolus florigerus.* On the other hand, the base of the fourth posterior cell is variable within *Neorhynchocephalus;* the European *N. tauscheri* (Fischer) always has this cell in contact with the anal cell, the width of the contact varying, being sometimes as wide as in *melanderi.*

It could be objected that *melanderi* might not belong in the Nemestrininae, since the proboscis is unknown and its existence is only inferred from the convex face. However, none of the living members of the subfamilies Trichopsideinae and Hirmoneurinae have a fourth posterior cell in contact at the base with the anal cell. In these subfamilies also a well-developed alula and three complete submarginal cells are found only in two subgenera of *Hirmoneura:* the living *Hyrmophlaeba,* which has pubescent eyes; and the extinct *Hirmoneurites,* which appears to have bare eyes. All species of *Hyrmophlaeba* known have, like the other species of *Hirmoneura,* the fourth posterior cell pointed at base (frequently stalked) and never in contact with the anal cell. The base of the fourth posterior cell of *Hirmoneurites willistoni* is not definitely known, but that species differs conspicuously from *melanderi* in the presence of an accessory crossvein in the second posterior cell.

The available evidence seems to support the view that *melanderi* was probably a species of *Neorhynchocephalus.* It is specifically distinct from *N. occultator* on the strength of the broad base of the fourth posterior cell. The difference in the shape of the base of the third submarginal cell is perhaps unimportant, since in some of the living *Neorhynchocephalus* this was found to be extremely variable within specific limits. If, however, it were shown that *melanderi* had a telescope-shaped ovipositor, it would most likely form a subgenus of its own within the genus *Nemestrinus.*

PROSOECA (PALEMBOLUS) FLORIGERA (Scudder)

Figures 6, 7 (5)

Palembolus florigerus SCUDDER, *1878,* U.S. Geol. Geogr. Survey Terr., Bull., vol. 4, pp. 519, 528; *1885,* in Zittel, Handbuch der Palaeontologie, Abt. 1, vol. 2, p. 808, fig. 1076; *1900,* idem., Eastman ed., vol. 1, p. 688, fig. 1467.—COCKERELL, *1908,* Am. Ent. Soc., Trans., vol. 34, p. 248; *1910,* Am. Mus. Nat. Hist., Bull., vol. 28, p. 286.
Palembolus florigerus HANDLIRSCH, *1907,* Die fossilen Insekten, pt. 7, p. 1009.—BROILI, *1915,* in Zittel, Grundzüge der Palaeontologie, vol. 1, p. 666, fig. 1454.—HANDLIRSCH, *1921,* in Schröder, Handbuch der Entom., vol. 3, p. 264, fig. 227.

The type at the Museum of Comparative Zoology (no. 3642, obverse and reverse), was examined by us. Scudder's description is accurate. Cockerell (1908) published some additional data, based upon an examination of the type by Mr. A. P. Morse. We may state that we have failed to find evidence of the "seam veins" in the right wing, which Mr. Morse thought might be present.

The type shows the almost complete insect in dorsal view, quite well preserved: proboscis, antennae, head, thorax, abdomen, and both wings can be studied with much detail. The proboscis is very long (over half the length of the body) and heavy, although the unusual width of the parts is undoubtedly due largely to flattening after death; the several parts are spread out; the wide labium, apparently fully extended, reaches beyond the tips of labrum and maxillae, and ends in two, well-marked, narrow labella; the other parts are stylet-like, the labrum rather wide, the maxillae very narrow. At the base of the proboscis, the face is considerably swollen, forming an unusually long snout. At the tip of the snout the two palpi can be seen, on either side of the base of the proboscis; they seem to be rather long and slender, but the segments are not distinguishable. The antennae are placed at the base of the facial snout, far apart, close to the lower inner orbits; the right antenna shows quite clearly the two terminal

segments, the last being pear-shaped, drawn out into a point bearing a style, which seemingly is longer than the antenna proper. The eyes are bare, very distinctly and broadly separated throughout by the frons and vertex; the inner orbits seem to be only a little nearer on the vertex than at the antennae. Entire frons and vertex are covered with long, black hairs. No ocelli could be made out. The thorax shows no special features, but is densely covered with black hair all over. The abdomen apparently consists of eight dark, dorsal sclerites, gradually narrowed from base to apex, separated by pale areas which increase in length from the base to the apex; the sclerites are densely covered with long, black hairs, which are particularly prominent on the sides and along the apical margin; the abdomen thus appears very strikingly banded crosswise and while this may have been partly true in life, it is nevertheless probable that the banded appearance was enhanced after death by the flattening and stretching of the intersegmental unsclerotized areas of the tergites; at the apex, there is a definite, knob-like thickening, evidently representing the male terminalia, as present in the living Nemestrinidae; this knob also bears numerous black hairs. In the wing, the alula is very considerably narrowed, almost rudimentary. The venation is almost exactly as in most living species of the genus *Prosoeca:* (*a*) there are only two complete submarginal cells, the first and second being fused; (*b*) the two branches of the third and the upper branch of the fourth longitudinal veins are curved upward at the tips (a feature characteristic of several, but not all, species of *Prosoeca*); (*c*) the fourth longitudinal reaches the diagonal vein a short distance beyond the branching off of the third longitudinal, so that the first submarginal cell does not touch the discal cell; (*d*) the diagonal vein extends beyond the second and fourth posterior cells to the hind margin of the wing; (*e*) the base of the fourth posterior cell is much narrowed and removed far from the anal cell; (*f*) the apical portion of the wing has no accessory cross-veins; (*g*) the submarginal and posterior cells all open broadly on the apical margin of the wing; (*h*) the sixth longitudinal vein is almost straight; (*i*) the costa encircles the wing completely.

The presence of the very long proboscis places *P. florigerus* without possible doubt in the subfamily Nemestrininae. The presence of only two submarginal cells, combined with the bare eyes, eliminate the following living genera: *Stenobasipteron, Trichophthalma, Fallenia, Neorhynchocephalus, Moegistorhynchus,* and *Nemestrinus.* In body characters and particularly in venation *P. florigerus* shows close relationship to *Stenobasipteron* and *Prosoeca,* two genera nowadays restricted to South and South Central Africa. *Stenobasipteron* has the alula very narrow, the base of the wing becoming long and stalk-like; otherwise it is like *Prosoeca.* The two genera are, moreover, rather poorly defined, some species of *Prosoeca* showing a decided tendency to narrowing of the alula. On the whole *florigerus* seems to be nearer *Prosoeca,* for although the alula is markedly narrowed, the base of the wing is yet broad, not in the least stalk-like. We are unable to point out a character by means of which *Palembolus florigerus* might be separated generically from all living species of *Prosoeca;* for even the wide frons of the male is found in some species of *Prosoeca.* It should be noted, though, that the development of the facial snout is rather unusual; in the living fauna it is duplicated only by certain species of *Nemestrinus* (such as *N. simplex* Loew). In *Prosoeca* and *Stenobasipteron* the face may be more or less prominent. Moreover, quite possibly the appearance of the snout-like face was exaggerated in *florigerus* by pressure during preservation.

The relationship of *florigerus* seems to be best expressed by referring it to the modern genus *Prosoeca,* retaining *Palem-*

bolus in a subgeneric sense. From the living species of *Prosoeca*, proper, *Palembolus* differs only in the narrow alula and the quite prominent face.

COMPARISON OF THE FOSSIL AND RECENT NEMESTRINID FAUNAS

1. The similarity of the Miocene Nemestrinidae with the living species is truly astonishing. As we have seen, they fit readily within the framework of the modern genera, showing only recombinations of characters found among the living species. In other words, the evolution of the family appears to have been at a standstill since the Miocene. Inasmuch as it showed even then a clear-cut differentiation into two main, short- and long-tongued, branches, it must have had an extended earlier geologic history. In this connection it is worthy of note that other families of insects, although equally old geologically, have undergone extensive modifications since the Miocene. None of the Florissant Mecoptera or Chrysopidae, for example, can be placed within existing genera, so marked have these changes been (5). But in the case of the Diptera in general and the Nemestrinidae in particular, there apparently has been no evolution since the Miocene, at least in the structure of the adults.

2. The abundance of Nemestrinidae in Colorado during Miocene times is no less remarkable, as Cockerell pointed out. If chance preservation and recovery has yielded thus far five quite distinct species, among eight specimens, the conclusion is fully warranted that the nemestrinid fauna of Florissant was very rich, probably similar in that respect to that of certain localities in Chile, Australia, South Africa or Turkestan at the present time. At any rate, it must have been considerably richer than that of present-day Colorado, where only one species has been taken thus far [*Neorhynchocephalus sackeni* (Williston); the occurrence of one or two more species in Colorado is, however, probable]. Moreover, in the entire Nearctic Region (from British Columbia to Florida, eastward, and to Yucatan and Guatemala, southward), the family is represented by only nine or ten living species, of three genera.

It is greatly to be regretted that the dipterous fauna of the Miocene of Florissant has never been adequately studied, so that it is impossible to estimate the relative importance of the Nemestrinidae at that geologic period. From the incomplete published data (referring to some 160 described species) and a cursory examination of unstudied material at the Museum of Comparative Zoology, at least the following families occur in the Florissant shales: Tipulidae (including Ptychopteridae), Chironomidae, Cecidomyidae, Mycetophilidae, Bibionidae, Phoridae, Pipunculidae, Syrphidae, Platypezidae, Empidae, Bombyliidae, Nemestrinidae, Tabanidae, Therevidae, Asilidae, Mydaidae, Leptidae (Rhagionidae), Stratiomyidae, Cordyluridae, Sciomyzidae, Heliomyzidae, Ortalidae, Muscidae (Anthomyidae), and Glossinidae. The dipterous fauna as a whole is not strikingly different from that of any warm temperate or

subtropical country nowadays. The fact that five of the 160 described species belong to the Nemestrinidae is of little if any significance, inasmuch as the specimens of that family have been specially selected from among a large mass of unstudied material. The only other families of Florissant Diptera adequately examined thus far are the Tipulidae, where Scudder reported no less than 60 species, and the Glossinidae, of which Cockerell described four species.

3. The Nemestrinidae of Florissant represent at least three well-marked genera. Two of these, *Hirmoneura* and *Neorhynchocephalus*, are nowadays found in the Nearctic Region, even in Colorado or nearby. The third genus, *Prosoeca*, is at present restricted to South Africa and its former occurrence in North America is therefore analogous to that of the Glossinidae or tsetse-flies. If it could be shown that *Neorhynchocephalus? melanderi* is really allied to *Nemestrinus*, a fourth genus, nowadays restricted to the Mediterranean Subregion, would be added to the Florissant fauna.

4. As we have shown in the discussion of the distribution, the vast majority of the Nemestrinidae are found now in subtropical countries with a warm, dry climate, at any rate in areas with dry, hot summers. Even most of the relatively few species that extend into tropical regions occur in the drier parts thereof, with a prolonged dry season. There seems to be no reason to assume that the environment in which the Nemestrinidae of the Florissant shales lived was essentially different, especially since the Miocene species differ so little from the living ones. In all probability the climate of Florissant, at that particular period of the Miocene, was like that prevailing nowadays in the western and southwestern United States.

REFERENCES

1. The network of lines in the wing of the Blepharoceridae is not comparable, since it is not formed of supernumerary veins, but merely of creases made by the folding of the wing in the pupal case. The nearest approach to the "reticulated wing" of some of the Nemestrinidae is found in certain genera of Cicadidae (*Cystosoma*, *Hemidictya*, and *Hova*) which possess a polygonal network, produced by accessory cross-veins in the apical half of the wing. In other genera of Cicadidae (*Polyneura*, *Angamiana*) and in some Fulgoridae, the reticulation seems to be of still another type. In Mr. Wm. T. Davis' collection the senior author saw specimens of *Odopoea poeyi* Guérin, of Cuba, showing a normal cicadid venation on which is apparently superimposed a slight, spurious reticulation entirely lacking in other species of *Odopoea*. Mr. Nathan Banks also pointed out to us that in *Hymenarcys*, a North American genus of Pentatomidae, the hind half of the fore wing has an irregular network of veins.
2. The senior author has reached the conclusion that the Australian genus *Exeretoneura* does not properly belong to the Nemestrinidae. It differs from all other members of the family in having apical spurs on all tibiae and a thick third antennal segment divided into annuli, without terminal arista. The venation is also quite aberrant, with the "diagonal vein" only barely indicated. The genus seems to be isolated in the present-day fauna and may perhaps best be raised to family rank.
3. De Serres, M., *Ann. Sci. Nat.*, vol. 15, p. 108, 1828; *Géognosie des Terrains Tertiaires*, p. 232, 1829.
4. Handlirsch A., *Die Fossilen Insekten*, Lfg. 4, p. 633, pl. 51, figs. 11–12, 1906.
5. Carpenter, F. M., The affinities of *Holcorpa maculosa* Scudder and other Tertiary Mecoptera: *New York Ent. Soc., Jour.*, vol. 39, pp. 405–414, 1931; Tertiary insects of the family Chrysopidae: *Jour. Paleontology*, vol. 9, pp. 259–272, 1935.

Note: The manuscript of this paper was received by the editor of the Journal, January 28, 1936.

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DATA ON THE RELATIONSHIPS OF LOCAL AND CONTINENTAL MAMMALIAN FAUNAS

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ABSTRACT

A comparison of Recent mammalian faunas of Florida and New Mexico, two remote regions differing essentially in climate and topography, shows that knowledge of either fauna will give a fair idea of the general composition of the other. It seems probable, for example, that such a fauna as that of the Bridger formation gives an excellent representation of the fauna of North America as a whole in medial Eocene time, and that broad inferences drawn from it are of higher value than is generally granted

The notorious incompleteness the paleontological record is due not only to gaps in time distribution of known fossils, but also, and at present in still greater degree, to the relatively local character of most of the faunas known. It is often necessary to judge the mammalian fauna of a whole continent or major land area from fossils found only at one or a few localities. For instance, the Eocene land life of North America is known almost exclusively from discoveries in a few basins scattered through the Rocky Mountain area. It is usual to speak of the Eocene fauna of North America, but in fact for any one part of the Eocene only a relatively very small and localized geographic group of that general fauna is known. Other instances are even more striking, as in South America, where almost all known pre-Pliocene mammals are from the relatively limited and marginal areas of Patagonia. It is obvious that such data cannot give a complete picture of the fauna of a whole landmass.

In the endeavor to visualize these relationships and to give some concrete basis for their evaluation, detailed comparison has been made between the Recent mammalian faunas of Florida and of New Mexico. The results, here set forth in outline, clearly are no more than an approach to the general problem, which requires very many more data for any full consideration or definitive solution. They do, however, suggest a means of approach which does not appear to have been utilized in this way previously, and they give some definite basis, however inadequate as yet, for judgment in an important matter hitherto generally ignored or treated by guesswork.

Florida has a land area of 54,861 square miles and a water area of 3,805 square miles. It is a marginal region and is almost surrounded by the sea. Physically it is low, with little relief or physiographic variety (maximum elevation, 325 feet; minimum, sea level; average 100 feet). The climate is oceanic and is warm and humid. Faunally, parts of the Lower Austral and Tropical zones

are included. The mainland lies between 25°07′ and 31° north latitude.

New Mexico has a land area of 122,503 square miles and a water area of 131 square miles. It is central in position and far from the continental borders. The physiography is extremely varied, including high mountains, plateaus, plains, desert basins, and low alluvial valley bottoms (maximum elevation, 13,306 feet; minimum, 2,876 feet; average, 5,700 feet). The climate is markedly continental, with hot summers and cold winters, and in general is semiarid. It includes parts or representatives of all fauna zones from Hudsonian to Lower Sonoran. It lies between 31°20′ and 37° north latitude.

The closest points of the two states are over 900 miles apart, and their centers are separated by about 1,450 miles. They are markedly different in position, environmental and physiographic variety, climate, and faunal zones. It is probably impossible to duplicate exactly in either an environment found in the other. They have in common the facts that both are distinctly parts of the North American continent of long standing, from the point of view of recent mammals, and that both lie in the southern part of the Temperate Zone.

The primary object of the comparison is to see what could safely be inferred of the fauna of the other if the mammalian fauna of only one of these two states were known. Hence some judgment is possible as to the limits of safe inference regarding the regional fauna in cases of fossil faunas known only from one part of a large landmass.

Lists of recent groups of land mammals of the two states have been compiled, and while no two students would agree as to exact numbers, the relative proportions are not greatly dependent on any personal factor. The following figures represent the number of orders, families, genera, and species (subspecies being excluded) of recent terrestrial mammals, exclusive of man and his importations, native to each state, and the numbers common to both.

	New Mexico	Both States	Florida	Total
Orders	6	5	5	6
Families	19	12	13	20
Genera	54	18	27	63
Species	133	6	33	160

The data for each state are more graphically comparable in fig. 1. The immediately striking fact is the greater variety of the New Mexican fauna, with four times as many species as Florida. The apparent reasons for this, in probable order of importance, are the greater environmental diversity of New Mexico, its larger area, and its more central position.

A second noteworthy fact is the markedly different ratios for different taxonomic groups. New Mexico has four times as many species as Florida, but only twice as many genera and half again as many families, while the number of orders is nearly the same. The two curves of the diagram consequently converge to the right. If comparable curves are plotted for areas still larger or still more varied than New Mexico, they

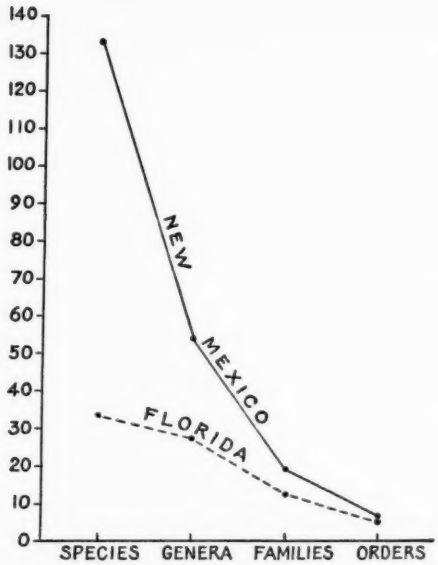

FIG. 1—Graphic comparison of the numbers of species, genera, families, and orders of recent, indigenous, land mammals in Florida and in New Mexico.

rise more and more steeply to the left, but the convergence to the right remains.

As regards this example, then, if we knew all the mammals of one state, we could infer almost exactly how many orders occur in the other, and fairly well how many families, but might be badly mistaken regarding the lesser units.

More important than the number of units is their character. Somewhat contrary to expectations, the example suggests that in similar cases and within certain broad limits, the character of the fauna of one region can be inferred from that of the other. These data are graphically shown in fig. 2, in which the elements common to both states are contrasted with those peculiar to one.

Another form of presentation is that of this table:

	Common to both states	Peculiar to one or the other	Florida fauna occurring also in New Mexico	New Mexico fauna occurring also in Florida
Orders	83%	17%	100%	83%
Families	60	40	92	63
Genera	29	71	67	33
Species	4	96	18	5

On this showing, knowledge of either fauna will give a fair idea of the general composition of the other, that is, of its orders and families. The possibility is also enhanced beyond the point indicated by the figures, and especially as regards smaller groups, by the fact that many mammals of each fauna have relatives in

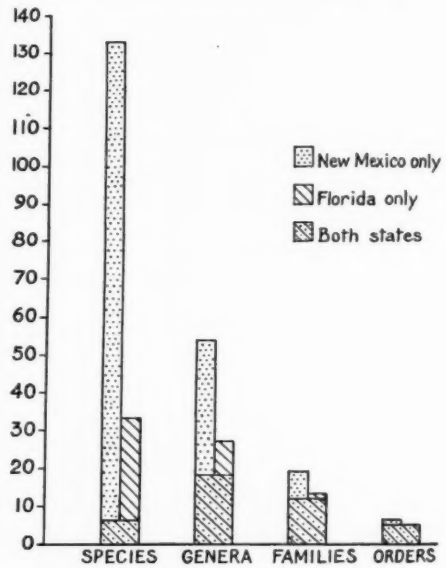

FIG. 2—Graphic tabulation of the numbers of species, genera, families, and orders of recent, indigenous, land mammals common to Florida and New Mexico and those occurring in one of these states but not in both.

the other which are not identical but which are so similar that knowledge of one is applicable in a general way to the other.

Another striking fact, although one that might be assumed *a priori*, is that the larger fauna gives a better basis for inference as regards the smaller than does the smaller for the larger. New Mexico, with its highly varied fauna, gives a reasonably accurate picture of the mammalian life of at least the central part of North America. If we knew its fauna and not that of Florida, we would nevertheless be familiar with all the orders, almost all the families, and two-thirds of the genera that do occur in Florida. Even beyond this, although for instance, we would not know *Neofiber* or *Geomys*, we would have the closely related and ecologically similar genera *Ondatra* and *Thomomys*. There would in fact be only one Floridian genus, *Scalopus*, which was radically unlike any known from New Mexico.

Applied to paleontological data, the accuracy of such inferences depends on numerous factors which can be approximately evaluated, although any close approach to statistical accuracy would necessitate the accumulation and interpretation of many more data than have yet been studied, and would even then be an extremely complex and difficult problem. There is, however, no reason to believe it insoluble. The main factors requiring such consideration are probably the following:

1. The area represented by the collection. This can be calculated, at least approximately, by the actual area covered by the geological formation, or by the probable size of the drainage area from which its fossils could have been derived. Accurate evaluation of this factor demands statistical data on the relationship of area and number of species under similar recent conditions.

2. Environmental variety. This can be estimated from the inferred physiographic conditions when the formation was being deposited, or perhaps more accurately from the nature of the fauna. A fauna which includes many cases of related but truely distinct contemporaneous species surely indicates environmental variety, for in general only one such species can live in one local environment, in one region, at one time (Cabrera's law of "ecological incompatibility"). Furthermore paleobiological inference may also indicate environmental variety, by indicating variety, or lack of variety, in the probable habits of the animals found.

3. Geographic position. It can be reasonably established on paleogeographic grounds and sometimes in part from the fauna itself, whether the region from which a given fossil fauna is derived was at the time of that fauna part of the large landmass under consideration, and approximately what position it occupied on that landmass. Presumably the more central the area, the more varied its fauna is likely to be and the better it will represent the continental fauna as a whole. The influence of broad climatic zones also needs evaluation. Presumably a large fauna would include nearly 100 per cent of the important groups of mammals present on the same continent in the same climatic zone, and in passing to other climatic zones the percentage would be progressively lower. Within a reasonable margin of error, this relationship could probably be established mathematically. In the case of Tertiary faunas the factor would be less important than with recent faunas, for the climatic zones were evidently much less marked during most of the Tertiary than they are at present.

4. Completeness of single faunas. Accuracy of broad inferences must be directly proportional to the extent of knowledge of the fauna on which the inference is based. It is probably impossible in any case to obtain fossil representatives of 100 per cent of the groups of land mammals that actually lived in a given area. The percentage of representation can be roughly estimated from the size of the collection made, the percentage of new species added by new collections, the relation of the number of species known to the number which probably were present under the given conditions, the presence or absence of representation of given groups known to have occurred both before and afterwards in the same region, and the ecological character of the fauna, that is, whether all environments probably present are represented, whether both herbivores and carnivores are present in normal proportions, whether both large and small mammals are present, etc.

It seems probable that a large and varied Tertiary fauna which may be judged representative on these criteria, even if it is from a single and fairly local geological formation, gives an excellent representation of the mammalian orders present on the whole continent, a good idea of the families, and will probably even include most of the genera.

As an example, the mammals of the Bridger fauna probably ranged over an area comparable to that of Florida. The position of their area was very central on the Eocene continent. The local environments represented are clearly numerous. Knowledge of the fauna is fairly complete. It follows that this fauna probably well represents the middle Eocene life of all of North America.

As an example of the sort of broader and more important inferences dependent on such data, the well known and apparently representative middle Paleocene faunas contain no possible ancestors of several Eocene orders and lesser groups. From the considerations here given, it therefore seems highly improbable that many of the typically Eocene groups were then present in North America, and failure to find them in the Paleocene cannot be entirely imputed to the localized nature of the known deposits of middle Paleocene age.

It seems probable that the paleontological data now in hand provide a better basis for studies of mammalian faunal succession and geographic distribution than is generally granted.

PALEONTOLOGICAL NOTES

THE FORAMINIFERAL GENUS *PALMULA* ISAAC LEA, 1833

HENRY V. HOWE
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ABSTRACT

Examination of the types of *Palmula* Isaac Lea, 1833, shows the genus to be identical with *Flabellina* D'Orbigny, 1839. It therefore replaces *Flabellina*.

So far as I am aware, the genus *Palmula* Lea was the first foraminiferal genus to be described from North America. It has apparently been overlooked by subsequent students of Foraminifera, presumably because its description was included in a volume devoted almost exclusively to fossil Mollusca. The full citation is as follows:

Lea, Isaac, New genus of fossil shell from New Jersey,—Description of a new genus of the Family *Spherulacea* of Blainville, from the deposit of Timber Creek, New Jersey: *Contributions to Geology*, pp. 219–220, pl. 6, fig. 228, Carey, Lea, and Blanchard, Publishers Philadelphia, 1833.

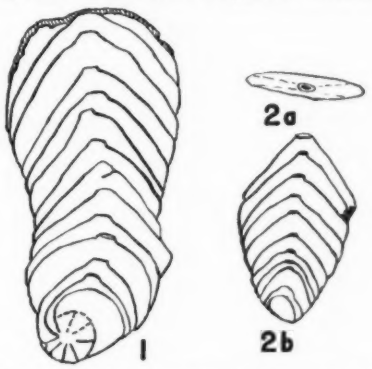
At my request, Dr. Richard J. Russell visited the Philadelphia Academy of Natural Sciences in December, 1934, and, through the courtesy of Dr. Henry A. Pilsbry and Dr. E. G. Vanatta, ascertained that Lea's types of the genus were still preserved there in excellent condition. In June 1935, I made a special trip to Philadelphia to study them, and found them mounted exactly as Lea had left them. I encountered considerable difficulty, however, as Lea had covered them with a thick deposit of shellac that required several hours careful work to dissolve with alcohol before the chamber arrangement, particularly in the early coiled portion, could be made out. I wish particularly to express appreciation of the courteous assistance rendered by Dr. Vanatta and to thank the Academy for permission to publish this article.

Lea's article is so short, and his treatise so rare that his original description is quoted in full:

GENUS PALMULA (*nobis*)

Description. Shell palmate, with angular striae, which indicate the interior chambers; aperture terminal.

Observations. Two specimens of the shell on which I propose to found this genus, were found by me, about four years since, in the Cretaceous deposit of Timber Creek, New Jersey. In its characters it approximates most



FIGS. 1, 2—*Palmula sagittaria* Lea, syntypes, ×6; 1, the larger specimen; 2, the smaller specimen, originally figured by Lea, (*a*) apertural view, (*b*) side view.

closely to the genus *Saracenaria* of Defrance. The oval form, the possession of a carina, and the absence of an aperture in that genus, prohibit our shell being placed with it. The *Palmula* also resembles the genus *Textularia* of the same author, and might, perhaps, with propriety be placed between these two genera.

P. sagittaria. Plate 6, Fig. 228

The small figure is of the size of nature.

Description. Shell depressed, sagittate, rounded on the edges, with about six angular striae, which indicate the interior chambers; mouth terminal, oval, sublabiate.

Diam. 1–20th, Length .2, Breadth .1 of an inch.

Observations. The two specimens differ somewhat in outline, the larger one being more elliptical. In both, the angular striae become obsolete at the base, being most distinct on the superior part.

Lea's types are both excellent specimens of a very large member of the Family *Lagenidae*. The larger specimen has a length of 8 mm. and a breadth of nearly 4 mm. The apertural end is broken, and the full length of the test may well have been as much as 10 mm. It was not figured by Lea, but is the more important specimen as the chamber arrangement of the initial end is much more distinct. It begins as a large *Cristellaria*-type coil, slightly more than a millimeter in diameter, following which the test becomes more compressed and the chambers take on the same inverted-V shape as in *Frondicularia*. The smaller specimen, figured by Lea, has a length of 4.62 mm., a breadth of 2.50 mm., and a thickness of approximately 0.50 mm. Its thickness is slightly greater near the initial end than in the fan-shaped later portion, and it is evidently coiled, but the shell material was too cloudy to make out the exact chamber arrangement. I made camera-lucida drawings of the chamber arrangement of both specimens which are given as figs. 1, 2. There seems to be no doubt that the genus *Palmula* Lea, 1833, possesses essentially the same characters as the genus *Flabellina* D'Orbigny, 1839 (Foraminifères, in De La Sagra, *Hist. Phys. Pol. Nat. Cuba*, p. 42), and, as it was described some six years earlier and the types are well preserved, in accordance with the Rules of Zoological Nomenclature Lea's name must take precedence over D'Orbigny's.

A NEW LAND SHELL FROM THE EOCENE OF CALIFORNIA

G. D. HANNA
California Academy of Sciences, San Francisco, California

Mr. H. E. Vokes of the Department of Paleontology, University of California, recently submitted to me a very interesting land shell that apparently has not been hitherto described. It is important that records be made of all such organisms that are discovered, in order that they may be used for correlation purposes whenever possible.

HELICINA VOKESI Hanna, n. sp.
Figure 1

Shell consisting of about $5\frac{3}{4}$ whorls, sutures well impressed; spire elevated, slightly convex; base evenly rounded, imperforate; aperture full, evenly rounded with a heavily calloused outer lip; sculpture consisting of relatively strong growth ridges; last whorl with a slightly concave spiral zone just below the suture, producing an ill-defined shoulder. Diameter, 8 mm.; altitude, 5.9 mm.

Holotype: Univ. California 15879, from UC. loc. A-1027, Domengine formation (Eocene), on the north side of the western end of the Vallecitos syncline, Fresno County, California. The collection is from approximately the point where the west meridian 120°40′ crosses Silver Creek, U. S. Geol. Survey topographic map, Priest Valley Quadrangle.

Helicina oregona G. D. Hanna was described in 1920 (Fossil mollusks from the John Day Basin in Oregon: *Univ. Oregon Publ.* vol. 1, no. 6, p. [4], pl. 1, figs. 3 *a–c*) from the

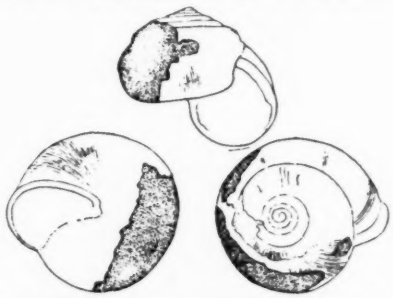


FIG. 1—*Helicina vokesi* G. D. Hanna, holotype, three views.

Oligocene of John Day Basin, Oregon, and the present specimen seems more closely related to it than to any other known at present. It has the same strongly ribbed surface, but it is slightly larger, has fewer whorls and a more axially inclined aperture; the presence of the shoulder is quite distinctive. No visible characters sufficiently important for generic separation of these species from *Helicina* are present.

HELIOCEPHALUS, NEW NAME FOR *MALVERNIA* DELO (NOT JACOBY)

DAVID M. DELO
Lawrence College, Appleton, Wisconsin

The writer recently described a new genus of trilobites under the name *Malvernia* (Jour. Paleontology, vol. 9, p. 411, fig. 20, 1935). It has been pointed out by Mr. Paul H. Oehser, however, that this name is preoccupied in Coleoptera by *Malvernia* M. Jacoby (Zool. Soc. London, Proc. for 1889, fasc. 2, p. 346). The writer, therefore, proposes to substitute for *Malvernia* Delo the name *Heliocephalus* (ἥλιος, sun; κεφαλή, head). The genotype becomes *Heliocephalus coronatus* (H. H. Thomas).

BRACHYASPIDION, NEW NAME FOR *BRACHYASPIS* MILLER (NOT SALTER)

B. MAXWELL MILLER
The Texas Company, Houston, Texas

Mr. Paul H. Oehser, in a letter dated February 26, 1936, has called to my attention the fact that the name *Brachyaspis*, recently proposed by me for a genus of Cambrian trilobites, is preoccupied, having been used as follows:

Brachyaspis, subgenus of *Asaphus* Brongniart, J. W. Salter, Paleontogr. Soc. Mon., British Trilobites, fasc. 3, p. 148, 1866. Crustacea: Trilobita.

Brachyaspis G. A. Boulenger, Catalogue of snakes in the British Museum, vol. 3, p. 353, 1896. Reptilia.

I propose, therefore, to substitute for *Brachyaspis* Miller (Jour. Paleontology, vol. 10, p. 28, 1936) the name *Brachyaspidion*, the genotype (p. 28, pl. 8, fig. 7) becoming *Brachyaspidion rhynchinum* Miller and the associated form (p. 28, pl. 8, fig. 8) becoming *Brachyaspidion*? sp.

PARENDOCERAS, NEW NAME FOR *SAFFORDOCERAS* ULRICH AND FOERSTE (NOT FOERSTE AND TEICHERT)

E. O. ULRICH and A. F. FOERSTE
U. S. National Museum, Washington, D. C.

The name *Saffordoceras*, with *S. nelsoni* Foerste and Teichert as genotype, was proposed in 1930 (Denison Univ., Bull., Jour. Sci. Lab., vol. 25, p. 264) for a genus of actinoceroid cephalopods. Hence *Saffordoceras* Ulrich and Foerste, 1935 (Denison Univ., Bull., Jour. Sci. Lab., vol. 30, p. 285), with *S. jeffersonense* Ulrich and Foerste as genotype, proposed for an holochoanoidal genus, is invalid under the Zoological Rules as an exact homonym. We therefore substitute for the invalid name the new generic name *Parendoceras*, the genotype becoming *Parendoceras jeffersonense* (Ulrich and Foerste).

SOCIETY RECORDS AND ACTIVITIES

PROPOSED CONSTITUTION AND BY-LAWS OF THE PALEONTOLOGICAL SOCIETY

The Council of the Paleontological Society, in accordance with the provisions of Article 8 of the constitution of the Society, presents for consideration by the membership a revised constitution and revised by-laws.

The existing constitution and by-laws may be found in the Bulletin of the Geological Society of America, volume 32, pages 150–156, 1921. Article 8 reads as follows:

1. This Constitution may be amended at any winter meeting by a three-fourths vote of all the Fellows, provided that the proposed amendment shall have been submitted in print to all Fellows at least three months previous to the meeting.

2. By-laws may be made or amended by a majority vote of the Fellows present and voting at any annual meeting, provided that printed notice of the proposed amendment or by-law shall have been given to all Fellows at least three months before the meeting.

A ballot by which approval or disapproval may be recorded will be supplied with the customary ballots for officers and members, and it is urged that all Fellows vote.

The changes proposed are necessitated largely by certain new circumstances that affect the operations of the Society: (1) The former relationship with the Geological Society of America no longer exists. In this relationship the Paleontological Society was designated an Affiliate; Fellows of the Geological Society who so desired automatically became Fellows of the Paleontological Society, and the dues of Fellows were paid by a rebate to the Paleontological Society of three dollars per year per Fellow from the dues paid to the Geological Society; the President of the Paleontological Society became during his term of office a Vice-President of the Geological Society. The Paleontological Society is now designated an Associate of the Geological Society, and there is no other stated relationship between the two organizations. (2) The Paleontological Society now joins the Society of Economic Paleontologists and Mineralogists in support of the Journal of Paleontology, with new responsibilities and new financial requirements. (3) There is an active Section of Vertebrate Paleontology, whose relations with the Society need definition.

CONSTITUTION

ARTICLE I

Name

This Society shall be known as The Paleontological Society. It is associated with, and was organized as a section of, The Geological Society of America. It shall, as a rule, meet with the Geological Society of America.

ARTICLE II

Object

The object of this Society is the promotion of the science of paleontology.

ARTICLE III

Membership

The Society shall be composed of Fellows, Members, Correspondents, and Patrons.

1. Fellows shall be persons who have published results of paleontological research, and who have been duly elected by the Fellows of the Society.

2. Members shall be persons not Fellows who are engaged or are interested in paleontological work, and who are duly elected by the Fellows and Members of the Society.

3. Correspondents shall be persons distinguished for their attainments in paleontology and not resident in North America, who have been duly elected by the Fellows of the Society.

4. Patrons shall be persons who have bestowed important favors upon the Society, and who have been duly elected by the Fellows and Members. Election to patronship carries with it the rights and privileges of Members.

5. Fellows, Members, and Patrons are entitled to vote.

ARTICLE IV

Officers

1. The Officers of the Society are a President, a Vice-President, a Secretary, a Treasurer, an Editor, the three ex-Presidents of the three preceding years, and the Chairman of each of the sections. These officers constitute a Committee to be called the Council.

2. The President shall discharge the usual duties of a presiding officer at all meetings of the Society and of the Council. He shall take cognizance of the acts of the Society and of its Officers, and cause the provisions of the Constitution and By-Laws to be faithfully carried into effect.

3. The Vice-President shall assume the duties of President in case of the absence or disability of the latter.

4. The Secretary shall keep the records of the proceedings of the Society, and a complete list of the Fellows, Members, Correspondents, and Patrons, with the dates of their election to and separation from the Society. He shall also be the Secretary of the Council.

The Secretary shall coöperate with the President in attention to the ordinary affairs of the Society. He shall attend to the preparation, printing, and mailing of circulars, blanks, and notifications of elections and meetings. He shall superintend other printing ordered by the Society or by the President, except for the Journal of the Society, and shall have charge of its distribution, under the direction of the Council.

The Secretary, unless other provision be made, shall act as Custodian of the property of the Society, except as provided for in Article IV, sections 5 and 6.

5. The Treasurer shall have the custody of all funds of the Society. He shall keep account of receipts and disbursements in detail, and this shall be audited as hereinafter provided.

6. The Editor shall supervise all matters connected with the publication of the Journal of the Society, under the direction of the Council. He shall also be the keeper of all publications sent to the Society.

7. The Council is clothed with executive authority and with the legislative powers of the Society in the intervals between its meetings; but no extraordinary act of the Council shall remain in force beyond the next following stated meeting without ratification by the Society. The Council shall have control of the publications of the Society, under provisions of the By-Laws and of resolutions from time to time adopted. It shall receive nominations for Fellows, Members, Correspondents, and Patrons, and, on approval by it, shall submit such nominations to the Society for action. It shall have power to fill vacancies *ad interim* in any of the offices of the Society not otherwise provided for. The Council may delegate its authority to an Executive Committee elected by the Council.

8. *Terms of Office.*—The Officers shall be elected annually. The President shall not be eligible for re-election until after an interval of three years from retirement from office. A Vice-President is eligible for re-election not more than once within such interval.

The Secretary, Treasurer, and Editor shall be eligible to re-election for not more than ten consecutive terms of one year each.

ARTICLE V

Voting and Elections

1. All elections shall be by ballot. To elect a Fellow, Member, Correspondent, or Patron or impose any special tax, shall require the assent of nine-tenths of all persons voting.

2. Voting by letter may be allowed.

3. *Election to Membership.*—Nominations for Fellowship must be made by two Fellows according to a form to be provided by the Council. These Fellows must be personally acquainted with the nominee and his qualifications. Members must be nominated by two Fellows or Members. The Council will submit the nominations received by it, if approved, to a vote of the Society in the manner provided in the By-Laws. The result may be announced at any stated meeting; after which notice shall be sent out to those elected.

4. *Election of Officers.*—Nominations for office shall be made by the Council or otherwise as provided for in the By-Laws. The nominations shall be submitted to a vote of the Society in the same manner as nominations for Membership. The results shall be announced at the annual meeting; and the Officers thus elected shall enter upon duty at the adjournment of the meeting.

ARTICLE VI

Meetings

1. The Society shall hold at least one stated meeting each year in the winter season. The date and place of this meeting shall be fixed by the Council, and announced each year within three months after the adjournment of the preceding winter meeting. The program of such meeting shall be determined by the Council in conjunction with the Council of the Geological Society of America and announced beforehand, in its general features. The details of the daily sessions shall be arranged by the Council of this Society.

2. The winter meeting shall be regarded as the annual meeting.

3. Special meetings of the Society as a whole or of any of its Sections as sectional meetings may be called by the Council, and must be called upon the written request of twenty-five Fellows for a general meeting, and of five Fellows for any of its sections.

4. The stated meetings of the Council shall be held coincidentally with the stated meeting of the Society. Special meetings may be called by the President at such times as he may deem necessary.

5. *Quorum.*—At stated meetings of the Society a majority of those registered in attendance shall constitute a quorum. Four shall constitute a quorum of the Council. Fifty persons shall constitute a quorum at special meetings.

ARTICLE VII

Publications

The publications of the Society shall be under the immediate control of the Council.

ARTICLE VIII

Sections of the Society

1. A Section of the Paleontological Society may be established by the Council upon the petition of twenty or more Fellows and Members.

2. The formation of such a Section must be authorized by a majority vote of the membership of the Paleontological Society present at an annual meeting, after three months' notice in writing has been given.

3. The Members of each Section shall be elected by the Section from the Fellows and Members of the Paleontological Society.

4. The Officers of each Section shall consist of a Chairman and a Secretary, to be elected by the Section, each to serve at the pleasure of the Section.

5. No Officer or Member of any Section shall have the power to incur, without the approval of the Council, any pecuniary obligation involving the Paleontological Society.

ARTICLE IX

Amendments

1. This Constitution may be amended at any winter meeting by a three-fourths vote of the Fellows and Members present or represented by proxy, provided that not less than a majority of all the Fellows and Members of the Society be present or represented by proxy, and provided further that the proposed amendment shall have been submitted in print to all Fellows and Members at least three months previous to the meeting.

2. By-Laws may be made or amended by a majority vote of the Fellows and Members present and voting at any annual meeting, provided that printed notice of the proposed amendment or by-law shall have been given to all Fellows and Members at least three months before the meeting.

BY LAWS

CHAPTER I

Membership

1. Fellows shall be elected by the Fellows of the Society, and Members by the whole membership.

2. The annual dues for all Fellows and Members shall be five (5) dollars. No person shall be accepted as a Fellow or Member unless he pays the dues for the year within two months after notification of his election. The annual dues are payable in advance on January first of each year.

3. An arrearage in payment of annual dues shall deprive a Fellow or Member of the privilege of taking part in the management of the Society and of receiving the publications of the Society. An arrearage continuing over two (2) years shall be construed as a notification of withdrawal.

4. The Council shall have power to waive the annual dues in whole or in part, in exceptional cases, but such an exemption may be rescinded by the Council at any time.

5. Any person eligible under Article III of the Constitution may be elected Patron upon the payment of one thousand (1,000) dollars to the Society.

Chapter II

Officers

1. The President shall countersign, if he approves, all duly authorized accounts and orders drawn on the Treasurer for the disbursement of money.

2. The Secretary, until otherwise ordered by the Society, shall perform the duties of Custodian of the property of the Society.

3. The Society may elect an Assistant Secretary.

4. The Treasurer shall give bonds, with two good sureties approved by the Council, in the sum of one thousand dollars, for the faithful and honest performance of his duties and the safe-keeping of the funds of the Society. He may deposit the funds in bank at his discretion, but shall not invest them without authority of the Council. His accounts shall be balanced as on the thirtieth day of November of each year.

5. The minutes of the proceedings of the Council shall be subject to call by any Member or Fellow of the Society.

6. The Council or Executive Committee may transact its business by correspondence during the intervals between its stated meetings; but affirmative action by a majority of the Council shall be necessary in order to make action by correspondence valid.

Chapter III

Election of Members

1. Nominations for all classes of membership may be proposed at any time on blanks to be supplied by the Secretary.

2. The form for nomination shall be as follows:

In accordance with his (or her) desire, we respectfully nominate for Fellow, Member, Correspondent, or Patron of the Paleontological Society: Full name; degrees; address; occupation; branch of Paleontology now engaged in; work already done and publications made.

(Signed by at least two Fellows or Members, as provided in Article V)

The Form when filled is to be transmitted to the Secretary.

3. The Secretary will bring all nominations before the Council before October fifteenth of each year. The members of the Council will signify to the Secretary their approval of each.

4. At least a month before the stated winter meeting of the Society the Secretary shall mail a printed list of all approved nominees for membership to each Fellow and Member, accompanied by such information as may be necessary for intelligent voting.

5. The Fellows and Members receiving the list will signify their approval or disapproval of each nominee, and return the lists to the Secretary.

6. At the next stated meeting of the Council the Secretary shall present the lists and the Council will canvass the returns.

7. The Council, by unanimous vote of the members in attendance, may still exercise the power of rejection of any nominee whom new information shows to be unsuitable for membership.

8. At the next stated meeting of the Society the council shall declare the results.

Chapter IV

Election of Officers

1. The Council shall prepare a list of nominations for the several offices, which list will constitute the regular ticket. This ticket must be approved by a majority of the entire Council. The nominee for President shall not be a member of the Council.

2. The list shall be mailed to the Fellows and Members, for their information, at least four months before the annual meeting. Any twenty Fellows or Members may forward to the Secretary other nominations for any or all offices. All such nominations reaching the

Secretary at least forty days before the annual meeting shall be printed, together with the names of the nominators, as special tickets. The regular and special tickets shall then be mailed to the Fellows and Members at least twenty-five days before the annual meeting.

3. The Fellows and Members shall send their ballots to the Secretary in double envelopes, the outer envelope bearing the voter's name. At the winter meeting of the Council, the Secretary shall bring the returns of ballots before the Council for canvass, and during the winter meeting of the Society the Council shall declare the result.

4. In case a majority of all the ballots shall not have been cast for any candidate for any office, the Society shall by ballot at such winter meeting proceed to make an election for such office from the two candidates having the highest number of votes.

Chapter V

Financial Methods

1. No pecuniary obligation shall be contracted without express sanction of the Society or the Council. But it is to be understood that all ordinary, incidental, and running expenses have the permanent sanction of the Society, without special action.

2. The creditor of the Society must present to the Treasurer a fully itemized bill, certified by the official ordering it, and approved by the President. The Treasurer shall then pay the amount out of any funds not otherwise appropriated, and the receipted bill shall be held as his voucher.

3. At each annual meeting, the President shall call upon the Society to choose two Fellows or Members, not members of the Council, to whom shall be referred the books of the Treasurer, duly posted and balanced to the close of November thirtieth, as specified in the By Laws, Chapter II, section 4. The Auditors shall examine the accounts and vouchers of the Treasurer, and any member or members of the Council may be present during the examination. The report of the Auditors shall be rendered to the Society before the adjournment of the meeting, and the Society shall take appropriate action.

Chapter VI

Publications

1. The publications are in charge of the Council and under its control.

2. One copy of each publication shall be sent to each Fellow, Member, Correspondent, and Patron.

Chapter VII

The Publication Fund

The Publication Fund shall consist of donations made as an endowment in aid of publication. Assets received for this Fund shall be kept by the Treasurer in a separate account, or accounts. Only the income from the Fund shall be expended, except by the unanimous vote of the Council, unless the terms of the donation specifically stipulate otherwise.

Chapter VIII

Order of Business

1. The Order of Business at winter meetings shall be as follows:

(1) Call to order by the presiding officer.
(2) Introductory ceremonies.
(3) Report of the Council (including report of the officers).
(4) Appointment of the Auditing Committee.
(5) Declaration of the vote for officers, and election by the meeting in case of failure to elect by the Society through transmitted ballots.
(6) Declaration of the vote for Fellows.
(7) Declaration of the vote for Members.
(8) Deferred business.
(9) New business.
(10) Announcements.
(11) Necrology.
(12) Reading of scientific papers.

2. At an adjourned session the order shall be resumed at the place reached on the previous adjournment, but new business will be in order before the reading of scientific papers.

3. At any Special Meeting the order of business shall be numbers (1), (2), (3), (10), followed by the special business for which the meeting was called.

THE PALEONTOLOGICAL SOCIETY OF JAPAN

Recent receipt of the first issue of the *Transactions and Proceedings of the Paleontological Society of Japan* calls attention to the formation of this society and affords occasion to extend a welcome to the new organization. The first president is Prof. Hisakatsu Yabe, and the headquarters of the society are in the Geological Institute, Faculty of Science, Imperial University of Tokyo.

The following information is taken from a circular issued by the society:

Stimulated by the already existing International Paleontological Union which was established in Washington in 1933, the Paleontological Society of Japan was founded in Tokyo on May 25, 1935, as a division of the Geological Society of Japan.

Articles by members are published in the column captioned "Transactions of the Paleontological Society of Japan" in the Journal of the Geological Society of Japan.

Reprints of articles appearing in this column are distributed quarterly to all foreign members.

The fee for foreign membership is $2.00 (American money).

All papers should be written in English, French, or German with a Japanese résumé, or vice versa. (Résumés in foreign languages may be translated into Japanese.)

The Paleontological Society of Japan desires your cooperation and welcomes your membership.

No. 1 of the Transactions and Proceedings includes 50 pages of text and 4 plates, and contains four papers in English dealing with Pleistocene mollusks, Miocene and Recent mollusks, Pleistocene plants, and early Paleozoic cephalopods; one in Japanese dealing with a Tertiary marine mammal (English résumé); and an account of the proceedings at the first meeting of the society. No. 2, in press, contains four papers in English dealing with fossil plants, Foraminifera, etc.